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Treasure Island in San Franciso Bay

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MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

Alas, the Paring Knife

ASSUMING the role of a private Consumers' Research, Bernard De Voto, who month by month occupies "The Easy Chair" on the back porch of *Harpers Magazine*, reports the results of his observations in the April issue in an article "The Paring Knife at the Crossroads."

Mr. De Voto has had good luck with automobiles. He rates the typewriter industry AA1; but when it comes to fountain pens he has "never had one write smoothly, flow ink freely (unless it also spouted ink), or could be maintained at the lowest conceivable level of decent performance." The foot switch that dims his automobile headlight functions perfectly; "why doesn't the electrical-goods industry make as good a switch for houses?" Although the householder is "best served by his heating and plumbing plants . . . . . you can drive an automobile at full speed all day long, using any kind of gasoline and taking it over any road, but if you are going to have trouble with an oil furnace you will get it during a subzero spell." "The door handle of your car has probably never come off—but how about doorknobs in your house?" And as for household goods—that's where the paring knife comes in. "The consumer wants a paring knife that will cut . . . . . If the cutlery business will not produce such a knife he is willing to put a government inspector in the factory and another on the books."

Mr. De Voto's views are his own and we may or may not share them. Whether it be in automobiles or hardware, typewriters or paring knives, much of the consumer satisfaction results from good engineering, just as consumer dissatisfaction may frequently be traced to bad engineering. Whatever else it proves, it demonstrates that there is still opportunity for engineers to serve the buying public if they are given the opportunity.

Whichever Way

IT IS easy to find fault with our institutions, particularly when they appear to have let us down. Examples come readily to mind. We criticize the Church, the educational system, the government. Sometimes we take it out in talk, sometimes in passive indifference, sometimes in active revolt. Sometimes we think they are fundamentally wrong and must be changed; sometimes that the times have outstripped them and they need rejuvenation; sometimes that the leaders are false, incompetent, or stupid, and we seek to turn them out. Frequently, the untried substitutes that we argue for appear to be brilliantly superior to what we have because we cannot forecast their faults. Usually, we fail to understand what we are criticizing, because most familiar institutions are taken for granted as portions of a common heritage and hence come into question only when they are suspected of failure. But in most cases if we examine them carefully, we find the situation is far from simple and the blame for the failure is variously divided. When this stage is reached there is hope for objective inquiry, out of which the institutions may be reborn to fulfill a larger destiny.

In common with many other institutions the American system of enterprise has been severely attacked as a result of world-wide economic and social disorders. From abroad come other philosophies, collectivistic as opposed to individualistic, that are sufficiently attractive to many on each end of our economic scale to place the American way on the defensive. From within our borders a variety of critics, actuated by a variety of motives, attack the system. Many believe in the system, but find its vitality at a low ebb, its practices out of tune with the times, its leaders reactionary, the institution itself static rather than dynamic and adaptable. Others frankly advocate its overthrow. Some regretfully announce that it is on the way out.

Whatever measure of comfort may be derived from the comments, criticisms, and attacks rests in the very fact that the institution is being re-examined and re-evaluated. Its survival will re-establish it more firmly than ever and revitalize it, because what men fight for they will dearly prize.

But survival of the American system of enterprise even in a form more sensitively adaptable to changed and ever changing conditions is by no means assured today. If we believe in it and desire it we shall be forced to fight for it. Nor is this merely a matter of composing conflicting differences of opinion and opposing group interests at home, important as this phase may be. For nearly a decade we have been trying to soften the effects of world-wide misfortunes. Each group has attempted to improve its position or at least to maintain its status. Some have succeeded, others have failed. But in so far as the nation at large is concerned, we are still facing the problems of unemployment, of national, group, and individual security, of mounting debt, of reduced production, of sick industries, of government in business and business in government, of inactive capital-goods markets, of faith in and loyalty to a system under which we have prospered. Day-to-day events convince us that a crisis is approaching. Its origin is in Europe. Regardless of what its outcome is there, the effects on this country are

likely to be more far-reaching than anything that developed out of the World War or the depression of the 1930's. We cannot avoid them.

It is a sobering experience to speculate on what the trend of events in Europe may mean to the American system of enterprise and to us individually and as a nation. Whether the democracies of Western Europe, the Axis powers, or the great unpredictable land of the Soviets triumphs, or a compromise resulting in "peace in our time" results, our way must be modified to adjust itself to the conditions the outcome will bring. The mental, spiritual, and physical energies of Europe are being exercised in preparation for a great struggle. Ours, normally directed toward the advancement of what we are pleased to call the standard of living, flounder at the level of stagnation, a poor way to prepare for inevitable competition and change.

To an individual the situation is confusing and fatalistic. So also it must have been on many occasions to those who built up our country and its institutions. To everyone and to engineers particularly—for modern life is essentially technological in character—the challenge is personal as well as collective. Survival must be considered in terms of straight thinking, hard work, and adaptability. These we must cultivate, whichever way events trend.

Paid Directors

LAST January, while he was still chairman of the Securities and Exchange Commission, William O. Douglas threw out the suggestion at a luncheon of the Fort Worth (Texas) Clearing House Association that corporations in this country would be better run if they were to replace some of their directors, who for a number of reasons abdicate their responsibilities, with "paid" directors, i.e., competent men wisely chosen and substantially compensated in line with their duties.

"The paid director," said Mr. Douglas, "would have no business interest other than serving on the Boards of a few corporations. He would acquire a thorough knowledge of these corporations, and he would sit as a representative of the public interest—particularly of the investing public which owns such a large part of our corporations and has so little influence in them. He would, of course, be elected by the stockholders. And his influence would, I believe, be immeasurable. Salaried, professional experts would bring a new responsibility and authority to directorates and a new safety to stockholders. The interests of the general public would also be more carefully considered than they frequently are today.

"With no conflicting interests whatsoever, the paid director could give his full attention to his company's affairs. He could visit the factories and the warehouses. He could know if the plant was being carried at too high a value; he could look not merely at statements of inventory but at the inventory itself. He would be able to penetrate the mysteries of the balance sheet and see the realities that lie behind it. He would not be merely a director at board meetings, he would be a director between board meetings as well. He could give the directing job more time in a week than many a director gives it in a year."

Mr. Douglas' proposal was much discussed at the time and has been since. Of its merits no estimate will be attempted here. It is said that our British cousins make use of the services of paid directors. Regardless of who may be represented, competence, intelligence, and attention to business are desirable qualities in the representative and perhaps the time will come when stockholders will pay the market price for them. If that time were to come, perhaps, as Mr. Douglas pointed out, "we would open up a new profession, a profession which would tap a tremendous reservoir of experience and wisdom, much of which finds no adequate outlet today."

Looking back at the record men with engineering training and background have made in industrial management, it is natural to suggest that men of this type would make equally as impressive records as paid directors, particularly for corporations engaged in industrial enterprises. As of today, probably most of the engineers who would qualify as paid directors are engaged in other equally important posts. But if the practice of electing paid directors became common, opportunities for the employment of engineers would be increased.

The Best Men Are Needed

FOR EIGHT months this magazine has been sent to nearly 6000 engineering students, more than half of whom will receive it for another eight months beginning with the October issue. What of the others? Some of those who will be graduated in June will become junior members. At the end of another year not all of this group will have retained membership. Such is the working out of adaptation and survival. Ten years—twenty years, and those who remain will be men of maturity, living in a different world under conditions no one can predict. But this too will be as it always has been.

Just as men have faith that the future will be different, so also they have faith that it will be better. Science, working through research, leavens life and quickens the mass of humanity. It will produce a better engineering profession made up of better engineers than the world now knows, men who have a clearer comprehension of the place of engineering in society. The need for such men will be great, because the technical problems will require greater knowledge and skill for solution, the social organization will be more delicately balanced, and the status of engineers as professional men will depend more and more on the sufferance of the people.

We live, we fail, we succeed as individuals. As a group we have continuity and significance. It is the mass of mankind that determines what the future will be. It is engineers as a group that determines what a profession will be. The decision of the best men to enter a profession makes the best profession, and the best men are needed and welcome.

The YOUNG ENGINEER FACING TOMORROW

By WILLIAM E. WICKENDEN

PRESIDENT, CASE SCHOOL OF APPLIED SCIENCE, CLEVELAND, OHIO

TO ANY of our older engineers who may have grown pessimistic over the future, an opportunity to rub elbows with you men yet in college ought to be a reassuring experience. You are facing life in an exciting period when change is the only certainty that can be counted on. As engineers you believe in change but distrust propaganda. You realize that the prevailing social scheme is not the product of design, but rather the residue of millions of trial-and-error experiments spread over ten thousand years of civilized history. What worked was retained; what failed was discarded. There is a time lag in this rule, but it works inexorably. When a Karl Marx or an Adolf Hitler goes into the silence and brings forth the blueprint of a new society, you view it with a healthy skepticism. The odds of experience are against it.

CURRENT EXPERIMENTATION

As engineers, however, we cannot remain satisfied with progress through trial and error. Our job calls on us to replace guesswork with rational planning wherever possible. We believe in experimentation, imaginatively conceived, rationally controlled, and rigorously checked. Our interest is roused by two decades of experiment with collectivism in Russia, in Italy, in Germany, and under less coercive guises in the United States. A critical stage in these experiments seems near at hand. The result? The pendulum seems to be starting its long swing back to the ideals of freedom. If that is true, it may mean much to you.

Some fruits of recent experimentation will doubtless endure. Bankers now accept the SEC instead of fighting it. Insurance men are reconciled to social-security measures. The utility interests expect government to develop water power. Industry, generally, is lining up for collective bargaining. Sober citizens who begrudge the waste of public funds on hastily improvised projects recognize the necessity for long-planned spending on public works as a counterpoise against violent swings of the economic cycle. Collective wealth is increasing faster than private wealth. Permanent gains are being made in the conservation of soil, water, and mineral resources and in public facilities for education, health, and recreation.

TO MAKE GOVERNMENT SERVICE BETTER

As civil engineers most of you may have more to do with public welfare than with private enterprise, and these new trends may largely shape your careers. A growing proportion of you will probably find careers in government service. This may be good for your profession by making a more even balance between the individualistic practitioner and the career man and by affording a wider choice between technical and executive types of responsibility. Equally, it should be good for government, helping to even the balance between social visionaries and fact-minded men.

If engineers are to take a larger part in government, it is the concern of all of us to make government a better place for engineers to work. We ought to pull together for fair compensation, for a more rational grouping of engineering functions, and for their removal from direct political pressure. This is not a remote issue; it may touch next year's bread and butter for many of you seniors. Honest engineering calls for clearly defined responsibility, for reasonable freedom of initiative, and for nonpolitical tenure. Do you want your job to depend on getting the initials of the right political boss? Do you want your decisions revised in the interest of the election returns? Do you want to be caught in a mesh of red tape? Can you expect to work well in a confused, overlapping, or isolated organization?

RECOGNIZING ECONOMIC FACTS

Facing tomorrow, it is time now to quit taking the economic world for granted. It will be well for you to reckon your stake in free institutions and in free enterprise. This principle of enterprise is not something remote or abstruse. It is the inner drive which urges men to get on and not merely to hold on, to depend on their own efforts rather than the paternalism of the state. It spurs the scientist to wrestle with nature, the inventor to strive for a novel product or a new way of doing work, the thrifty man to sacrifice in order to save and to own, the financier to take the risks of a new industry, the engineer to plan, and the executive to organize for increased efficiency.

What we call capitalism is the fruit of freedom and enterprise in the world of work. Free enterprise, it is pretty generally agreed, will work well only in an expanding economy. In the past, spreading frontiers, virgin resources, and rising population have supplied the expansive force. Now we have to seek it in raising the general standard of living of a population predominantly urban and industrial.

ENGINEERS PROSPER WITH INDUSTRY

Free enterprise, when wisely directed, tries to raise living standards by multiplying wealth, while state paternalism almost always ends up in attempting a solution by dividing it. Every engineer knows that permanent gains in wealth and leisure are the by-products of rising efficiency, and cannot be created by government subsidy; that the way to cure unemployment is to create more jobs through research, thrift, and enterprise, by developing new products, by creating new industries, and by translating technical advances into reduced prices and wider markets. One quarter of all our employment today is said to be in industries which did not exist before 1880.

In our modern industrial society we thrive not merely through what we spend for goods quickly consumed, but through what we spend to put more men to work. On the average, it costs about $7600 today to equip a worker for his job. The flow of new capital into investment has all but stopped under a public policy of policing industry rather than encouraging it, and there is little prospect of healthy recovery until it is

Although this address was made to a group of civil-engineering students in St. Louis, it is of interest to all young engineers and is published in the hope that it will be of general benefit.—Editor.

re-established. The accumulated deficit of capital replacement and new investment of the last decade has been estimated at something like 150 billions. This is a vital matter to engineers. We spend the money which prepares jobs for men, directing it through construction and manufacturing channels into wages and purchases of materials, through which it ultimately is transformed into purchasing power for consumption goods. Engineers can thrive only when society thrives by multiplying its economic capacity.

A CRITICAL CHOICE

Facing tomorrow, you are facing the risks of decision which mark off the man from the boy. Heretofore, most of those risks have been taken for you by parent, school, or teacher. You will be tempted, in the spirit of the times, to prefer security to adventure. Most of you who do so choose will settle into mediocrity. If you have not had the privilege of going away from home to college, try for a job in some other town. Finish the job of growing up, if possible, out from under the wings of the family and the college which reared you.

The engineer does not shun risks, but he takes them prudently. It will be important to you to choose a field which challenges you, but one in which you can succeed by reasonable application and effort. Success is a habit, and not a lucky break. Education comes through success, in getting a taste of achievement which creates a craving for more. Men are lured to success, not driven. If you succeed it will be because you are spurred by inner drives rather than by outside rewards.

You will begin life in a competitive struggle, but with the odds in your favor. President Compton of the Massachusetts Institute of Technology, reporting on a study of 54,000 officers of 500 corporations, has stated that the college man is seven times more likely than a noncollege man to become such an officer, but that an engineer is thirty times more likely than a nonengineer. The advantage is great, but it is well to judge the odds in the light of changing conditions. Going to college has become a generally accepted social habit, much as going to high school became twenty-five years ago. One young person in seven enters college today. Place beside this fact another, namely, that about one family in seven is above the income level of $2400 per year, and it is plain that college-going has about caught up with preferred opportunity in our present society.

ON YOUR OWN

The odds are with you, but they will not save you from the relentless sifting of the first five years out of college—the most critical period of an engineer's career. The shock of passing from college, where everything conspires for your development, to a realm of repetitive work has been likened to shifting a fast-moving car from high to low gear. It is a jolt to find that you are expected to go on with work after you feel that you have exhausted its learning possibilities, to find yourself and most of those about you using so little of what you learned in college, to have a boss who pushes you on output while you have to push him if you wish to learn anything. You will find that where a hundred men will learn under the organized routine of a school, or ten under the inspiration of a voluntary group, only one will keep driving ahead under his own power.

When you discover that you must now fight your own battle for self-development, you will be tempted to work for yourself rather than your employer. You will want to be a brilliant performer and to go places in a hurry, with dreams of a vice-presidency at thirty. Then someday you may awaken to the fact that too much zeal of this kind is holding you back, that you are really heading for one of those "lone-worker" jobs which are blind ends in most organizations. At this stage, a good football player is likely to hold an advantage over a brilliant scholar. To get ahead on the main track, you will have to learn to put your organization first and adjust yourself to the tempo of group activity. You will have to get others to perform and not merely perform yourself. You will have to learn to judge men, fit them to their tasks, train them, iron out their troubles, check their performance, appraise and reward their work, and inspire them with organization spirit.

SURMOUNTING ROUTINE

Educators of all sorts are observing that young engineers stand the shock of adjustment to the world of work better than college men in general. They have a clearer sense of direction. Fewer of them flounder. They know the worth of discipline. Sustained work is no novel experience, nor does physical effort appall them. Few are troubled with conflicts of personality. They accept economic realities. Employers have long since recognized these qualities, and the depression years have emphasized the engineer's preferred position. To you seniors facing tomorrow these are grounds for self-confidence, but not for overconfidence. The make-or-break test lies just ahead. The critical question is "Can you surmount routine?" Every good college of engineering trains men for careers of decision and action. Their opportunities are boundless, but they set their own limitations of achievement.

Cushing, N. Y.

SAN FRANCISCO—OAKLAND BAY BRIDGE TAKEN FROM TREASURE ISLAND, THE SITE OF THE GOLDEN GATE INTERNATIONAL EXPOSITION. A.S.M.E. SEMI-ANNUAL MEETING IN SAN FRANCISCO, JULY 10–15. SEE PAGES 407–409 OF THIS ISSUE

METAL CUTTING

Principles Underlying Mechanism of Cutting Metals With Single-Point Tools; Machinability Measurement and Control; Selection of Machinable and Tool Materials

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TOOLS FOR CUTTING and machining metals are indispensable to modern manufacturing economy. The purpose of this paper is to present some of the fundamental principles of metal cutting, a thorough understanding of which is essential for the success of each metal-cutting application. Complete understanding of the subject, however, must proceed from a consideration of elements and fundamentals.

For the sake of definiteness as opposed to generalities, the scope of this paper will be confined to metal-cutting tools, mainly for single-point turning as in a lathe, which is the basic machine tool. Under the mechanism of cutting will be discussed the nature and magnitude of cutting forces, chip formation and chip removal, and effect upon work. Under the heading of machinability, an effort will be made to define this rather elusive property or characteristic of metals, and the principal means of measurement will be described. Means to control machinability as well as selection of machinable materials, tool design, and, in conclusion, the selection of cutting-tool materials will be considered.

A single-point cutting tool is more like a punch than a wedge because the material is not so much split as pushed. The tool compresses the material ahead of the point or nose and escape of the material so compressed involves tensile, bending, and shearing stresses resulting in rupture, segmentation (in the case of brittle metals), or plastic deformation and flow in ductile metals.

Brittleness is suddenness of failure or the property of breaking without warning, that is, without visible permanent deformation. It is the opposite of ductility in that it involves rupture without deformation. Ductility is the ability to be permanently deformed by tension without rupture, or specifically, the ability to be drawn from a larger to a smaller size of wire which involves an elongation and a reduction of area. It is distinguished from toughness in that ductility is the quality of being deformed by tension without rupture whereas toughness is resistance to deformation (1).[1]

CUTTING FORCES

Cutting forces are of two general types, those which act upon the tool and the machine and those which react upon the work being machined. Of the two forces, that due to the rotation of the work in turning is called the *tangential force*. The cutting force resulting from feeding the tool into the work is termed the *longitudinal force*, and the thrust which tends to separate the tool and work or shove the tool back in its holder is called the *radial force*. These three components of the forces exerted on a metal-cutting tool in service are capable of separate measurement by means of dynamometers. The simplest type is that employed for a planer or shaper and is known as a loop dynamometer. A tough or springy flat ring of metal is interposed between the platens of a compression-testing machine and calibrated for various static loads in connection with a reliable dial indicator which measures the degree of collapse of the flattened ring under compressive loads of known magnitudes. The ring and dial indicator are then placed in the planer or shaper in such a way that the force acting on the cutting tool can be measured. For measurement of cutting forces in lathes, hydraulic, mechanical, and electrical dynamometers have been developed and widely used.

With regard to the effects of the cutting forces on the work, recent photoelastic studies have contributed valuable and definite information on the analysis of magnitude and distribution of stress resulting from machining. The method consists in viewing transparent plastic materials, such as celluloid or bakelite, with polarized light while the specimens are subjected to loads simulating actual cutting forces. The resulting interference patterns and fringes make clearly visible the stress distribution, and further analysis permits actual evaluation of stress gradients throughout the specimen. Much has been done by Hans Ernst, member A.S.M.E., and research engineer of the Cincinnati Milling Machine Company, in this field (2). He has also made use of paraffin, which possesses the unusual property of becoming more opaque in regions which have been highly stressed. When a punch or cutting tool is slowly pressed against a block of this material, the propagation of internal stress, finally resulting in rupture and removal of segments like those of chips observed during the cutting of metal, can be clearly seen.

CHIP FORMATION

Chip formation differs for different metals and, sometimes, for the same metal with different physical conditions resulting from thermal or mechanical treatment. Brittle materials like cast iron crush into small fragments of irregular size including finely divided powder. Brass tends to form serrated segments of nearly uniform pitch, while ductile materials like steel form chips which are semicontinuous ribbons. Chip formation is also affected by cutting speed, amount of feed per revolution, depth of cut employed, and, under specific conditions, by the design of the tool and its rake angle.

No discussion of chip formation would be complete without a few remarks concerning chatter. Carl Oxford defines chatter as a synchronized vibration set up in the cutting tool, the work, the machine, or a combination of one or more of these elements. It is usually related to a lack of rigidity; for example, it may be caused by tool deflection resulting from excessive overhang, by deflection and consequent vibration of some part of the tool or work-holding structure, by excessive backlash in the driving mechanism, or by certain irregularities in the behavior of the built-up edge and chip flow. Even in the

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Paper presented at a meeting on Feb. 14, 1939, of the Bridgeport Section of The American Society of Mechanical Engineers.

cutting of brittle materials which are resolved into small and irregularly sized fragments by crushing and shearing, the cutting pressure usually does not fall to zero at any time during cutting but undergoes a wave-like variation from a maximum to a minimum with relatively uniform frequency. Resonance may occur which will cause the various elements to vibrate in unison, resulting in severe chatter.

Although it has been claimed that materials can be cut with less power consumption under chatter conditions, the effects of this condition are almost entirely detrimental. The constant and frequently severe hammering which cutting edges of tools receive contributes to premature failure and, in most cases, unsatisfactory machined finish. Chatter can usually be avoided by some slight change in the cutting conditions, such as increasing or decreasing the cutting speed; eliminating looseness in the machine, tool, and work-supporting structures; changing the hardness of the work through heat-treatment; and modifying the tool angles or applying additional support in the form of a steady rest, follow rest, or spindlebrake.

CHIP REMOVAL

In the removal of chips from ductile materials, a condition known as the built-up edge is invariably encountered. In nature, this built-up edge is continuous with both the chip and the work and comprises the highly stressed region ahead of the tool point, usually a laminated structure resulting from successive layers of material being dragged back from the underside of the flowing chip. The crystalline grains in the chip, usually cubical or equiaxed unless the material has been cold-worked below its recrystallization temperature, will be found to be elongated at right angles to the tool face or direction of chip flow. The grains of the laminar layers of the built-up edge will be elongated parallel to the tool face or direction of chip flow. Despite these differences in orientation of plastic crystalline deformation, the built-up edge, the chip, and the work are continuous in the region just ahead of the advancing tool nose.

The built-up edge is intensely hard by virtue of the extreme strain hardening which accompanies its formation. Because of this work hardening, the material of the built-up edge is appreciably harder than either the metal in the main body of the work or of the rest of the chip itself and becomes the actual cutting implement which, under certain conditions, envelops the entire working edge of the tool as well as portions of the flank and tool face adjoining the working edge, protecting these regions from abrasive wear which would result from their contact with the moving work and chip. To some extent, the built-up edge is always present in cutting ductile metals. Under certain conditions, it may be highly transient because it is formed almost instantaneously as turning is begun, and is built up and suffers losses through sloughing off with the work or chip, while under other cutting conditions, it may be relatively permanent. The cause is a result of confining material to the tool-nose region by compression and frictional resistance which does not permit escape by lateral flow. The results are many and fundamentally important to the cutting of all ductile metals.

The built-up edge obviously forms the optimum rake angle for the material being cut under specific conditions of operation and, therefore, controls the angle of chip incidence upon the tool face. The impingement of the chip on the tool face causes a crater or chip cavity located behind the cutting edge at a point which is dependent upon the extent to which the built-up edge envelops and protects the region immediately adjacent to the cutting edge. However, if a tool with a flat top or only slight side rake is used, the angle of incidence of the chip upon the tool face will be nearly perpendicular and will tend to accelerate top wear. The greater the side-rake angle, the less will be the angle of chip incidence upon the tool face which will minimize resistance to chip flow and, also, top wear. In roughing work with deep cuts, heavy feeds, and relatively slow speeds, the built-up edge will protect the tool cutting edge from abrasion. The flank, however, will suffer severe abrasion due to the frequent escape of intensely work-hardened sections of the built-up edge with the work. These portions of the built-up edge which remain attached to the work are highly detrimental to the machined finish, and it is to this cause that the torn, rough finish of roughly turned work must be attributed. The machined finish is improved by minimizing the size of the built-up edge and promoting its intermittent escape with the chip rather than with the work.

When the cutting is intermittent, as in the case of milling, the built-up edge is more highly transient than in turning. The life of the built-up edge in milling is limited for any particular tooth to the interval during which that tooth is passing through the work. An examination of the underside of the chip discloses the built-up edge attached to the trailing end of the chip. The dynamic nature of built-up edge formation in intermittent cutting, as in milling, presses the lower layers of the built-up edge against the tool face so tightly that seizure occurs. When the tooth leaves the work, the built-up edge, in attaching itself to the trailing end of the chip, is torn from the tool face and carries with it a small accretion from the tool itself. Each time a tooth impact with the work occurs, a cavity is generated on the tool face, which ultimately spreads to the cutting edge causing shear of the thin section and resulting in the appearance of chipping on the cutting edge. If the tool continues to cut, the rubbing may result in an apparent wear which masks the chipping.

TYPES OF CHIPS

The most recent classification (2) of chip formation involves the division of chips into three types. Type 1 is a discontinuous chip which is produced when cutting brittle material under a heavy feed with a low cutting speed and a small rake angle, and, naturally, its disposal presents no difficulty. Under conditions which produce a relatively fine pitch of chip segments, a good finish is conferred upon the workpiece. With this type of chip, the tool actually scrapes the machined surface and little or no built-up edge is present. Tool failure occurs by rounding of the cutting edge and abrasion of the clearance flank.

The type-2 chip is formed in cutting ductile material when light feed, high cutting speed, steep rake angle, keen cutting edge, and the optimum temperature at the tool point are used and means for easy chip flow across the tool face are provided. This can be accomplished by lapping the tool face, applying an effective cutting fluid having lubrication properties, and using a tool material which has an inherently low coefficient of friction. In this type of chip the built-up edge is not only smallest in magnitude but highly transient, and it escapes periodically and frequently with both chip and work without ever attaining great size. Under these conditions, the cutting edge is in intermittent contact with the work itself, and failure occurs partly by the rounding over and abrasion of the clearance flank as well as by the development of a chip crater on the face of the tool. The type-2 chip is the most desirable in machining ductile materials and the conditions of cutting should be adjusted to permit both of its attainment and maintenance.

Type 3, like type 2, is a continuous chip but the built-up edge instead of being transient is more or less permanent and larger in magnitude. The frequent escape of large portions of the built-up edge with the work causes the clearance flank to recede through wear until the wall between the worn flank and

the chip cavity generated on the tool face is so thin that breakage occurs and the tool must be resharpened.

EFFECT OF CUTTING CONDITIONS

Cutting conditions have a profound effect upon the structure, characteristics, and properties of not only the machined surface, but the underlying layers as well. The equiaxed crystal structure characteristic of hot work and annealed materials is destroyed to a depth dependent upon the cutting speed, the depth of cut, and the feed per revolution. The material is work- or strain-hardened and rendered unstable mechanically due to residual stresses. E. G. Herbert (3) has shown that the hardness or tensile strength of a bar of steel in an unstrained and unworked condition at room temperature can hardly be a reliable index to the machinability of the same bar under the conditions which obtain during metal cutting. Not only does the cutting operation generate considerable heat, a portion of which is absorbed by the work, but a considerable region ahead of the advancing tool nose is in a severely cold-worked condition. The actual metal which the tool must crush, bend, and tear in the process of removing a chip is in many cases several times as hard, strong, and abrasive toward the cutting edge as when machining of the bar is begun. The extent of work hardening in the chip exceeds that in the work.

Herbert shows that in many cases the chip has been so severely distorted that maximum work hardness has been imparted to it. Bierbaum (4) found that certain bearing metals when machined with dull tools suffered grain distortion beneath the cut surface. Such cold working is highly undesirable in a bearing, and it was concluded that surfaces of such bearings could best be finished by precision boring with sharp diamond cutters involving a depth of 0.001 in. or less at very high speed and fine feed. Digges (5), of the Bureau of Standards, investigated the quantitative effect of cutting conditions on the hardness of carbon and alloy steels. Comparisons were made of the work hardening resulting from changes in size, form, and composition of tools, speed, feed, and depth of cut as well as composition and heat-treatment of the steels machined.

The amount of work hardening was not influenced by changes in the cutting speeds of lathe tools. With a given area of cut, the amount of work hardening was affected equally by changes in the feed or depth of cut. The effect depends not only upon the cutting conditions, such as the area of cut, but also upon the composition and heat-treatment of the steels being machined. Stainless steel of the familiar 18-8 composition, not free-machining, had a high capacity to work harden near the machined surface even with small areas of cut, but with increase in area of cut, change in work-hardening values was not so marked. Work hardening the 18-8 stainless steel in lathe tests to the extent of increasing the surface hardness from 40 to 100 per cent had no marked influence on the resistance of the steel to hot nitric acid, indicating that the cold work did not seriously affect the corrosion resistance. It is obvious that parts which are to be roughly machined without the removal of the highly stressed layers underlying the machined surface by means of lighter cuts and feeds, or other means, such as grinding that involves less severe stress conditions, should be subjected to some sort of stress-relieving heat-treatment to remove the mechanical instability which might easily result in distortion in service.

DEFINITION OF MACHINABILITY

Like hardness, machinability is a rather intangible property or characteristic of materials. No comprehensive and satisfactory definition has yet been proposed which meets all of the requirements. Neither has any single test been devised to measure machinability satisfactorily in order to permit the relative classification of the materials cut with edged tools under the widely varying conditions encountered in shop practice.

The difficulty obviously lies in the many aspects which machinability presents. It is a function of so many variable quantities that the basis of measurement and intended use of the information must be clearly and definitely specified in each case. The simplest definition describes machinability as the relative ease or difficulty of cutting with edged tools. More technically, machinability has been held to be a measure of the internal resistance to rupture of a metallic crystalline structure by a cutting tool. Boston (6) defines machinability as the ability of a cutting tool to perform or the ability of a material to be machined. Ernst (2) offers a three-part definition: First, the ease with which a chip may be removed, that is, the true machinability is probably a direct function of the tensile strength of the material; second, the ease with which a good finish may be obtained, which means the ease with which a type-2 continuous chip is achieved or approached, in cutting ductile materials, therefore, probably an inverse function of ductility; and third, the tendency of the material to abrade the tool, which is the negative property, abrasiveness. In connection with this definition, it must be remembered that the characteristics to be measured should be measured at the temperatures and under the conditions of strain hardening which obtain in the region adjoining and just ahead of the tool point during actual cutting.

TESTS FOR MACHINABILITY

Perhaps, the clearest understanding of machinability will emerge from a brief consideration of the tests for or measures of machinability. One of the favorite methods is to indicate the "Taylor speed," which is the cutting speed used with a tool of standard size and shape under fixed cutting conditions corresponding exactly to a 20-minute tool life. A shorter method involves determining tool life under specified cutting conditions. By a third method, machinability is measured by the rate of penetration of a drill under constant pressure or the time or number of strokes necessary to saw through a piece with a hack saw under constant pressure. Measurements of force, energy, or power required for taking a cut of specified proportions are frequently employed in machinability tests. Besides the types of dynamometers already mentioned for estimating pressures in planing and turning, those for measuring torque and thrust are used in connection with drills and other fluted tools. A fifth measure of machinability is a determination of the cost per cubic inch removed. This operating cost is composed of a power cost, a tool cost, and the cost of the labor involved.

IMPROVING MACHINABILITY

Machinability is frequently taken to be a function of the temperature developed at the tool point during cutting. This temperature is measured either with a tool-work thermocouple or with a tool thermocouple. Occasionally, machinability is estimated by a measurement of surface quality resulting from the machining operation; the degree of superficial finish being measured with a profilometer. Machinability can frequently be estimated and predicted by consideration of the nature and characteristics of the workpiece, including composition, heat-treatment, hardness, tensile strength, ductility, microstructure, and shape (including relative strength or fragility of the section). As a last measure of machinability, it has frequently been said that, if a piece of work will go through the shop without inducing the foreman to curse roundly, the piece may be safely pronounced machinable.

It has been found that the cutting process destroys the normal

structure of the work not only on the machined surface but to some distance beneath the surface as well. It is this distorted, work-hardened material which the tool is cutting and not the material as it leaves the rolls or heat-treating operation prior to machining. Obviously, if metal can be cut under conditions involving a minimum of distortion and strain hardening only a small volume of metal, machinability will be greatly increased and costs will be correspondingly reduced.

Considerable progress has been made in recent years in developing the so-called free-machining steels. Treatment and compositions have been evolved which render such ordinarily extreme work-hardening types as 18-8 stainless steels relatively free-cutting. Bessemer and open-hearth screw stocks have been improved by additions of sulphur and the control of grain size and nonmetallic inclusions. Improvements have recently been made in aluminum alloys which are claimed to make these materials freely machinable in screw machines. Brasses, particularly those which are leaded, have always been found to be of excellent machinability in automatic repetitive production machines. More recently efforts have been made to render free-cutting steels still more adaptable for use as screw stock by means of additions of lead. The extent of benefit in this direction has not yet been proved, but it appears that the lead serves to break up the tough and ductile ferrite as well as to provide a measure of lubrication.

CHIP CONTROL

From the standpoint of screw-machine operation, the most important aspect of machinability, other than minimum tool-wear effects necessary to adequate tool life between sharpenings, is the problem of chip control and disposal. Power consumption and finish are likewise important factors, but with the crowding of tools, which is characteristic of screw-machine setups, it is vitally necessary that a close-curling, short-breaking chip be obtained. The chips from wide form tools must be readily collapsible so that interference with adjacent tools can be avoided. Free-cutting steels for automatic machines must have or acquire during cutting a certain brittleness for best machinability. Bessemer screw steel possesses the property of decreasing very sharply in impact strength as it is cold-worked and this characteristic contributes to its machining qualities. In addition, good free-cutting steel must not harden too sharply under the cold working it receives during machining. Otherwise, the abrasive effects upon the cutting tool would make for short life between resharpenings and result in high cost of idle time and resetting to gage after tool changes. In other words, good free-cutting steel must be soft and brittle, which is a rather unusual combination of physical properties.

The characteristics of maximum machinability differ materially from those which make the part after machining most suitable from the standpoint of service requirements. The metallurgist seeks to impart through heat-treatment a maximum of strength, hardness, and toughness, and resistance to bending, penetration, abrasion, and rupture. Massive parts of relatively simple shape can frequently be heat-treated after machining, particularly, if the parts are to be finished by grinding. A great variety of parts, however, are of such fragility and intricate shape that it is most desirable to machine them after heat-treatment to correct the distortion incident to hardening. The machinability of such items with ordinary cutting tools is so low that recourse must usually be made to sintered-carbide-tipped tools. These superhard cutting-tool materials extend the range of machinability far above the top hardness values that permit economic production with tool-steel tools. Even glass, weld-deposited stellite, chilled iron, and armor plate can be machined with sintered-carbide tools.

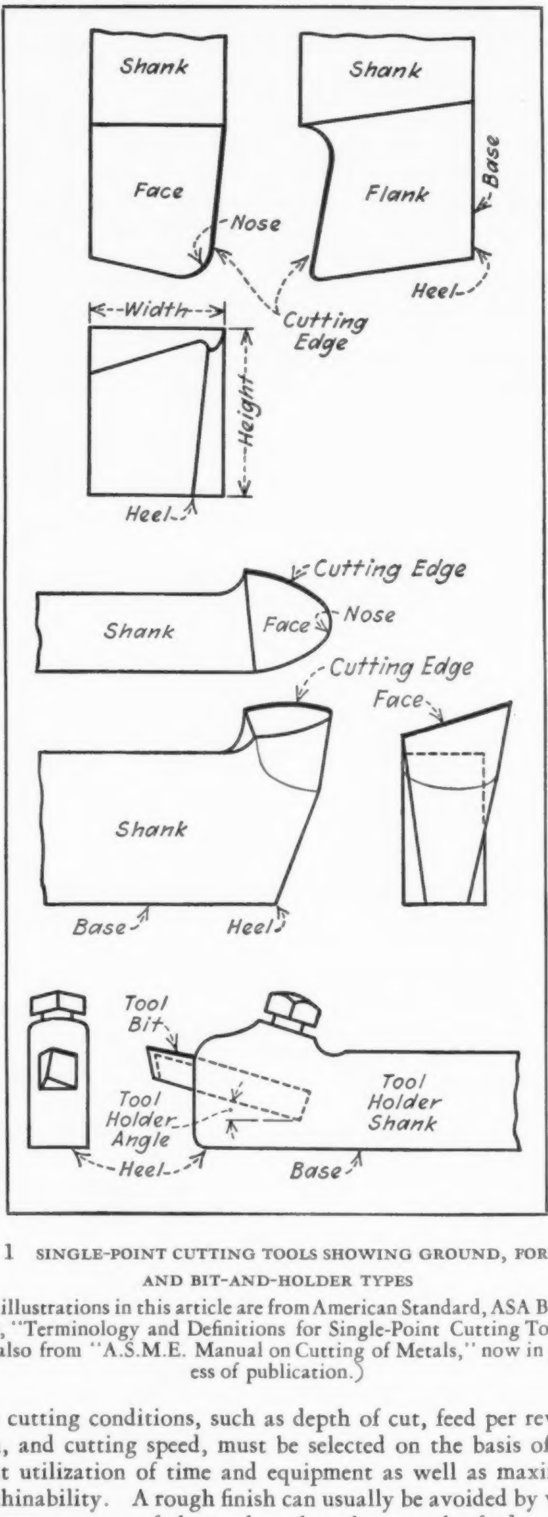


FIG. 1 SINGLE-POINT CUTTING TOOLS SHOWING GROUND, FORGED, AND BIT-AND-HOLDER TYPES

(All illustrations in this article are from American Standard, ASA B5.13–1939, "Terminology and Definitions for Single-Point Cutting Tools," and also from "A.S.M.E. Manual on Cutting of Metals," now in process of publication.)

The cutting conditions, such as depth of cut, feed per revolution, and cutting speed, must be selected on the basis of efficient utilization of time and equipment as well as maximum machinability. A rough finish can usually be avoided by varying one or more of the tool angles, the cut, the feed, or the speed.

Of the metallographic constituents of steel, ferrite, or iron without carbon, is the softest, the most ductile, and has the lowest tensile strength. It is usually reported as of low machinability because the physical characteristics of the material are such as to form a large built-up edge. The chip clings to the tool and cannot be easily broken, and the result is a torn surface and wear on the tool. Maximum machinability is achieved by adjusting machining conditions to approximate a

type-2 chip with intermittently escaping built-up edge. This result is largely obtained by increasing the rake and the cutting speed. At the other extreme is cementite, or iron carbide, which is intensely hard and brittle, having an almost complete lack of ductility. Cementite and ferrite occur in many steels in a variety of forms, principally, lamellar pearlite and spheroidized pearlite. In the former, the cementite and pearlite are arranged in layers of tabular plates. Cutting this aggregate obviously involves tearing the ferrite and breaking the cementite. Mechanically, these sharp-edged plates of cementite cause severe abrasion on the cutting edge of the tool. However, these cementite plates may be converted by the process of divorce annealing into rounded globular particles or spheroids distributed through a ferrite matrix as nests of temper carbon. If the treatment is continued too far, the spheroids increase in size to a point where their abrasive action on the tool increases. This is due to the fact that with small spheroids the cutting action is largely one of tearing the ferrite and pushing the cementite globules aside, whereas, beyond a certain critical size, it is necessary for the tool to cut through them in the process of chip removal.

Sorbite is an aggregate of ferrite and cementite in which the particle size and degree of dispersion are respectively smaller and more complete than in the case of either pearlite of lamellar structure or spheroidized form. Consequently, sorbite is more abrasive toward a cutting edge than the other two. It has a fair degree of strength, hardness, and ductility, none of which is particularly suited for ready machining. The physical properties of this structure, however, make it highly desirable for certain service requirements, and it is, therefore, often necessary to machine steel in the sorbitic condition.

Austenite is an aggregate of carbon with gamma iron. This distinguishes it from all of the foregoing metallographic constituents which involve carbon and alpha iron. The metallographic appearance of austenite suggests ferrite because the dispersion of the carbon is so great that the particles cannot be distinguished even under high magnification. The composition, hardness, and other physical properties of austenite may vary widely and so, obviously, must its machinability, since machinability varies inversely with hardness. With steel tools, the austenitic manganese steels are almost impossible to machine and frequently the chrome-nickel stainless steels, while not termed unmachinable, require, like other extreme strain-hardening materials, the use of sintered-carbide-tipped tools.

Armour (7) states that machinability of plain carbon non-heat-treated steels increases with carbon content up to about 0.3 per cent. This statement is doubtless based on the contention that the embrittling action of increased carbon, while increasing the abrasive effect upon the cutting edge, renders the chip much more susceptible to control and breakage. The dispersion of the carbon through the relatively soft ferrite breaks up the latter's continuity and prevents an extended tearing action which would contribute to poor finish. Manganese in quantities up to 1 per cent increases both the hardness and brittleness of steel and, therefore, contributes to the easy machining characteristics of the low-carbon steels. Sulphur is the element most commonly employed to give low-carbon steels free-machining properties. In the form of manganese sulphide, this material appears in rolled steel as nonmetallic inclusions which assist the pearlite in breaking up the otherwise continuous soft and ductile ferrite. Manganese sulphide, which is much more brittle than pearlite, and acts in somewhat the same manner, does not increase the hardness or strength of the steel and, therefore, equivalent amounts enhance machinability more than pearlite.

Machining of metals involves rupture which is more largely intra- rather than intercrystalline. All crystals have planes of cleavage or easy slip, and, inasmuch as propagation of slip through fine-grained materials requires the transfer of rupturing force in constantly changing directions because of the random orientation of grains, a coarse-grained material is more readily machinable than a fine-grained steel. Armour (7) divides the alloy elements into those which form carbides and those which dissolve in the ferrite. As an example of the former, chromium steels exhibit much the same machinability as carbon steels of lower carbon content because of the strength-increasing tendency of the chromium carbides. Elements which alloy with the ferrite toughen the matrix and render such alloy steels less machinable. The customary treatments of annealing and normalizing can usually be employed to render both types of steel comparatively easy-machining.

TOOL DESIGN

The objectives of tool design are maximum cutting efficiency and economy. These involve the least possible energy consumed in unnecessary chip distortion and the least rapid wear on the tool, as well as maximum durability and the attainment of the greatest possible productivity, both as to volume and quality without sacrificing accuracy and finish. Tool design cannot neglect many of the variable factors which determine the results and, although, many of the effects of the individual elements of tool design are exercised jointly, each of the many variable quantities will be described separately.

TOOL ANGLES

Under the subject of tool angles, it will be found that increasing the rake angle facilitates chip flow and escape from the region of the tool nose, minimizes the size and effects of the built-up edge, cutting pressure, power consumption, and cutting temperature. Usually, the finish is improved and chip distortion and strain hardening are limited. Excessive rake, however, weakens the tool, lowers heat conductivity, and may induce chatter or cause digging in. Increasing the clearance angles provides free cutting action, minimizes power consumption and force on the tool, and decreases cutting temperature. Excessive clearance, however, weakens the tool and may also cause chatter and digging in. Increasing the setting angle or angle which the side cutting edge makes with the work axis increases cutting-edge engagement and cutting pressure as well as power consumption and tendency to chatter; but the gain in durability or tool life frequently offsets the disadvantages. Boston (6) reports that the Taylor speeds for 90-, 60-, 45-, and 30-deg setting angles stand in the proportion of 1.00, 1.21, 1.48, and 1.87. The 30-deg setting angle, although resulting in an 87 per cent increase in tool life, causes excessive chatter and is considered impractical. Frequently, a setting angle of 45 deg will cause highly objectionable chatter.

CUTTING-EDGE CONTOUR OF TOOL

Under the classification of cutting-edge contour, increasing the nose radius from $^1/_{32}$ to $^3/_4$ in. increases the cutting force by about 13 per cent. A larger nose radius, however, increases durability, but also increases cutting-edge engagement, power consumption, tendency to chatter, chip distortion, and cutting temperature. Maximum chip distortion and its attendant detrimental effects appear to occur when the nose radius is equal to the depth of cut. A large nose radius for heavy roughing work will often help to eliminate chatter which might be encountered if the cutting edge were straight instead of curved. With the curved edge, chip thickness varies continually and chip slippage occurs in such a way as to inhibit resonance or the repetition of regular vibrations which constitute chatter. In planning cutting-edge contours, it should be remembered

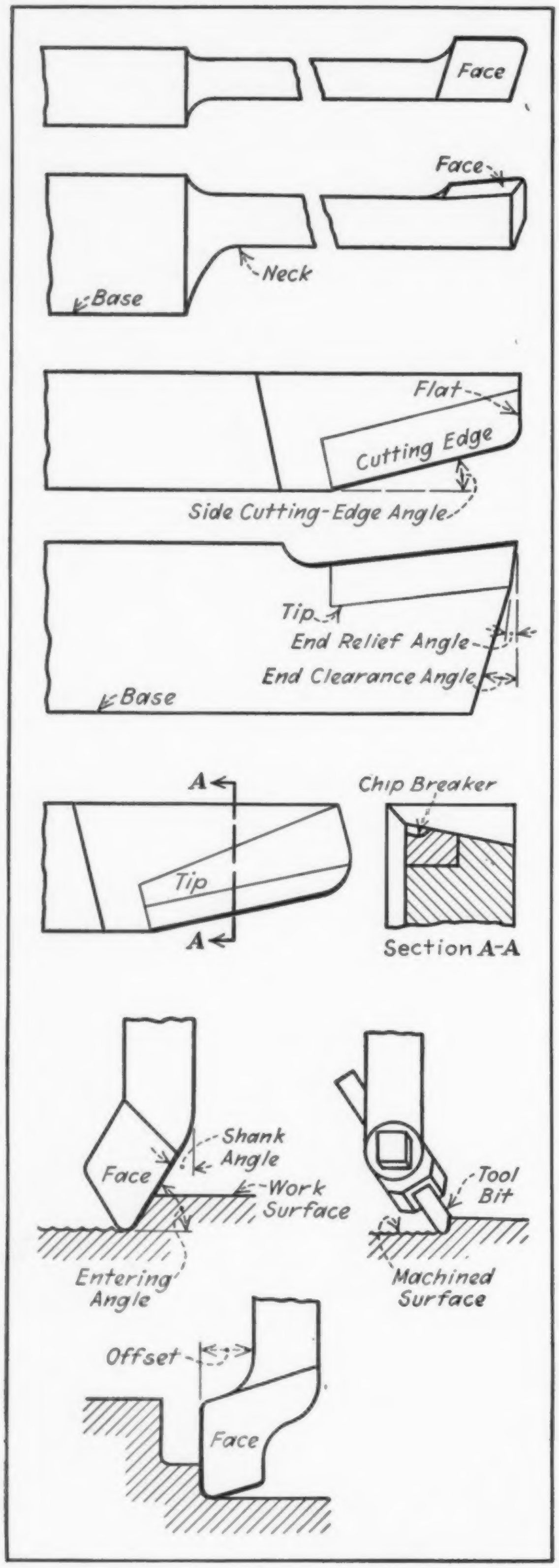


Fig. 2

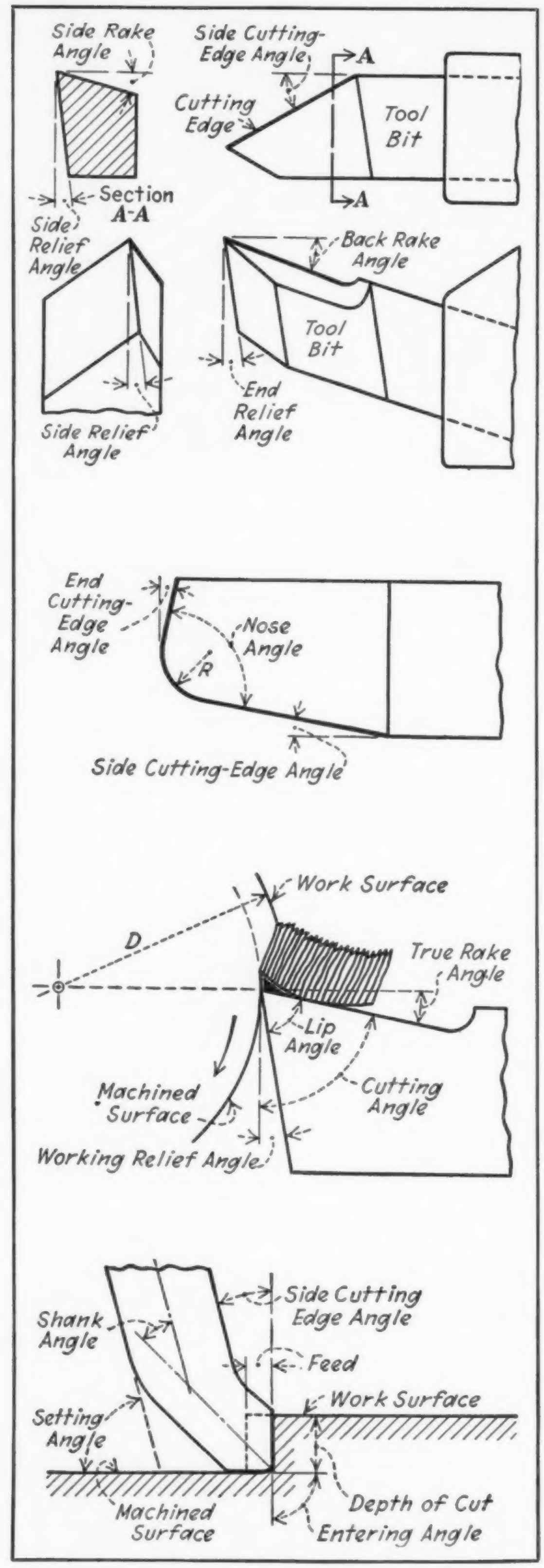


Fig. 3

FIG. 2 SINGLE-POINT CUTTING TOOLS SHOWING BORING, STRAIGHT-TIPPED WITH CHIP BREAKER, BENT SOLID AND TIPPED, AND OFFSET TYPES

FIG. 3 SINGLE-POINT CUTTING-TOOL ANGLES

that wear is always greatest at sharp corners where the direction of the cutting edge changes abruptly. All unnecessarily sharp intersections should, therefore, be blended by stoning or lapping. Excessive cutting-edge engagement on fluted tools can frequently be avoided by means of staggered chip-breaking notches or grooves.

The cutting conditions, such as speed, feed, depth of cut, and cutting fluid, are usually dictated largely by the requirements of each individual case, such as cost, finish, and accuracy, as well as the necessary production rate. Where latitude exists, however, the cutting conditions should be adjusted to effect the most satisfactory compromise. Increasing cutting speed shortens tool life, minimizes built-up-edge effects, improves finish, and increases power consumption and cutting temperature. Increasing the feed increases the cutting efficiency, lowers the power consumption per unit of material removed, but increases the over-all power consumption as well as the cutting force and work-hardening effects. Increased feed shortens tool life, but increases the production rate and minimizes the abrasion of the cutting edge. Increasing the depth of cut increases the force and power as well as the strain hardening of the work and the cutting temperature, but shortens tool life proportionately much less than an equivalent increase in feed. For roughing work, therefore, a moderate feed with as deep a cut as practical constitutes cutting conditions which foster maximum cutting efficiency. The use of a suitable cutting fluid lowers the cutting temperature, increases the speed for a given temperature, lengthens tool life by minimizing abrasion, and facilitates chip flow through lubrication.

The type of cutting tool is usually determined in large measure by the machining operation to be performed, the part to be machined, and the machine tool to be employed. The size of tool should always be as large as possible in order to absorb the forces developed in cutting without deflection which would destroy accuracy and damage the tool. The shape of tool selected should be one which will best absorb the cutting forces and provide the best possible support for the cutting edge. In forming tools, particularly in automatic machines, it is customary to employ the skiving principle to provide a shear cut to eliminate chatter through minimum cutting-edge engagement and to minimize the distortion and deflection of fragile workpieces. In milling, the pitch of the teeth should be designed so that more than one tooth is always engaged with the work in order to discourage chatter, and, frequently, helical teeth which provide a shear cut will be found desirable.

SELECTION OF CUTTING-TOOL MATERIAL

If there is one most important phase of tool design, it is probably cutting-tool material selection. An almost endless variety of materials are cut with edged tools in an almost endless number of ways. It is natural that there should be a large number of types of cutting-tool materials in order that each class of material and type of machining operation may be performed with the greatest possible efficiency. The selection of the one best material for a specific application can only be made after a careful study of all discoverable information concerning the proposal. The factors determining cutting-tool material selection may be divided into: the machining operation, the machine tool to be used, the material to be machined, the part to be machined, and the machining conditions, such as production, accuracy, finish, and other service requirements.

The machining operation must be identified as to type and nature, which is turning or milling—roughing or finishing. The style, size, and design of the cutting tool must be decided. The type of machine tool to be used must be considered as well as its age and condition. The means for supporting and locating the work as well as the tool-holding facilities must be checked. The material to be machined should be studied in detail and its physical form, properties, chemical composition, heat-treated condition, and machinability must be determined and the relative magnitude of probable chip pressures estimated. The shape and relative strength or fragility of the part will have an important bearing on tool-material selection. If the piece is irregular, an intermittent cut requiring a tough, shock-resistant grade of cutting-tool material will result. If the part is thin-walled and springy, a hard, wear-resistant tool, which will retain its keen cutting edge for long periods with low cutting pressure, is indicated.

Straight-carbon tool steels are suitable for most cutting applications where neither heat nor abrasion are particularly severe factors. Tungsten, chromium, vanadium, molybdenum, and cobalt are added to carbon steels to increase their wear resistance and ability to retain hardness at high temperatures encountered in high-speed cutting. Several inherently hard nonferrous cast alloys are available which have outstanding red hardness. Their hardness is due to composition since they do not respond to heat-treatment. They must either be cast to shape or ground, as they are practically unmachinable except with sintered-carbide-tipped tools or diamonds.

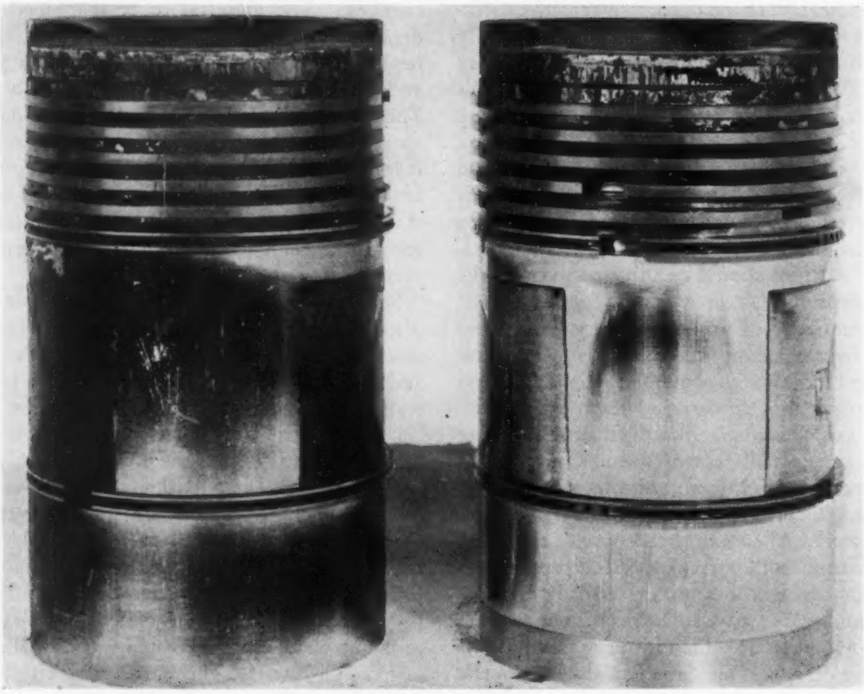
The most recent development in cutting-tool materials is that of sintered carbides. These superlatively hard and wear-resistant materials are made by the methods of powder metallurgy. Ordinarily, the hard-metal tips are used as inserts in tool-steel shanks, so that the carbide forms the actual cutting or working edge of the tool. In smaller sizes, particularly for precision boring, solid tool bits are commonly employed.

The first sintered carbides were almost entirely composed of tungsten carbide and cobalt in varying proportions to produce grades covering a range of hardness and strength necessary to machine different materials under varying conditions. Of all the heavy metals which form carbides, the carbide of tungsten is probably the hardest and the most wear-resistant. It will cut all metals with comparative ease and will even scratch sapphire. It is exceeded in hardness only by diamond.

While sintered tungsten carbides are unequaled for machining cast iron, brass, and other nonferrous as well as nonmetallic materials, such as the highly abrasive molded plastics, difficulties were early encountered in attempts to machine steel. While possessing the requisite hardness and resistance to wear to cut even the hardest steels, sintered tungsten carbide, unfortunately, has both a high heat conductivity and a high coefficient of friction. These characteristics render the material unsuitable for cutting steel which is the densest material cut with edged tools. Most steels machine with a semicontinuous chip which is in almost constant contact with the flank and lip surfaces of the tool. High-speed cutting generates enough heat to decompose the tungsten carbide through oxidation. The high coefficient of friction relative to the sliding chip accelerates wear on both the flank and in the chip cavity which forms on the face of the tool.

Experience showed that tantalum carbide had both of the characteristics desired for machining steel, namely, low-heat conductivity as well as resistance to oxidation at elevated temperatures and, most important, a very low coefficient of friction against steel. Unfortunately, tantalum carbide is earthy in nature while tungsten carbide is more truly metallic in character. Difficulties were experienced in bonding tantalum carbides with the conventional cobalt binding alloys because of the limited solubility of tantalum carbide in cobalt. It was found that only a small proportion of tantalum carbide was necessary to bring about the desired effects. The next improvement, therefore, took the form of adding a small amount of tantalum carbide to a base of sintered tungsten carbide. In

(*Continued on page 378*)



(a) (b)

FIG. 1 TWO PISTONS FROM SAME ENGINE

[(a) Operated for 375 hours with mineral oil; (b) operated for 2000 hours with mineral oil containing an additive agent.]

Some Factors in the LUBRICATION *of* HIGH-SPEED DIESEL ENGINES

By A. T. McDONALD

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SATISFACTORY lubrication of an internal-combustion engine, once taken for granted as being accomplished when the crankcase was filled with oil, has developed into one of the most complex and involved problems for the modern engine builder. This is due, in part, to the rapid advances made in engineering and design in the last few years which have resulted in greater pressures, higher speeds, and higher outputs of engines. This is particularly so in the case of aircraft and high-speed Diesel engines.

The rapid development of the high-speed Diesel engine and its acceptance as a dependable and economical source of power brought about the realization that the demands placed upon ordinary lubricants by this type of engine were far beyond their limits of stability, oiliness, and film strength. Because high-speed Diesel engines are most satisfactorily lubricated by special lubricants, and since this paper deals primarily with the lubrication of this type of engine, the author feels that it is advisable at this point to give a brief review of the development of specially manufactured lubricants for this purpose.

The arrival of efficient high-speed Diesel engines with their higher pressures and more critical piston-ring belt temperatures resulted in frequent failure of the engine due to liner scuffing or to piston-ring sticking. After exhaustive experimental activity in the way of engineering design had failed fully to justify these failures, serious thought was given to a study of the lubricant in seeking a solution to the problem.

The first step along these lines was the further treatment of lubricants to achieve a state of higher chemical stability (as measured by various accelerated oxidation tests). This, in most cases, resulted in an increase of difficulties rather than a decrease. Cooperative research by the engine builders and the lubricant manufacturers disclosed the fact that overtreatment of lubricating oils was not only possible but also as injurious to the lubricating qualities of a lubricant as insufficient treatment. After exhaustive tests, certain stocks were selected as representing the optimum in balance between purification and the retention of all desirable lubricating qualities. Still, even these carefully manufactured lubricants fell far short of providing satisfactory lubrication. It was at this point that additive agents were introduced to increase film strength, oiliness, and resistance to oxidation. These compounds, when added to basic stocks of proper origin and treatment proved of inestimable value in the lubrication of high-speed Diesel engines.

Presented at Peoria, Ill., Sept. 15, 1938, at a regular meeting of the Central Illinois Section of The American Society of Mechanical Engineers.

An example of the relative merits of straight mineral oil and a specially compounded lubricant designed for the lubrication of a high-speed Diesel engine is shown in Fig. 1 in which (*a*) represents a piston which had operated 375 hours in a Caterpillar Diesel engine using as a lubricant a straight mineral oil, and (*b*) represents a piston after 2000 hours' operation in the same engine under identical operating conditions using the same oil plus one per cent of an additive agent commonly used in the manufacture of Diesel-engine lubricants. The effectiveness of this type of additive is quite apparent and needs no further explanation here. There has been so much misconception, however, of the manner in which these additives function, that for purposes of clarification, the following description of this phenomenon seems to be in order.

Failure through ring sticking is generally brought about in two ways. First, the chemical decomposition of the lubricant results in the formation of a hard, lustrous, and practically insoluble lacquer-like material on the piston surfaces, which, combined with carbonaceous material, acts to cement the ring firmly in its groove. Second, lack of film strength in a lubricant results in metal-to-metal contact of the bearing surfaces in the high-pressure regions, causing rings and liners to scuff or score, which results in abnormal blowby with consequent poor combustion and causes sooty or gummy depositions, or both, from combustion which, when combined with excessive depositions from the lubricant caused by high temperature as a result of the high blowby, also cement the ring in its groove. In the first case the additive acts partially as an oxidation inhibitor, reducing the quantity of deleterious materials formed. In addition to this, it has the effect of increasing the detergent quality of the oil. This added detergency or cleansing power has the effect of removing, during the incipient stages of their formation, the aforementioned carbonaceous and binder materials. Consequently, bearing surfaces stay relatively clean and the rings remain free. The second and equally important function of the additive is to increase film strength to such an extent that sufficient safety factor is provided to prevent metal-to-metal contact under the most severe conditions of pressure and temperature.

All lubricating oils contain, in varying percentages, natural oxidation inhibitors, and film strength and oiliness compounds. The additive agents used in the manufacture of special Diesel lubricants (metal soaps) are added, not to give an oil new qualities, but to increase the effectiveness of those already inherent in the lubricant.

Another very important problem has been that of bearing lubrication. Bearing failures are caused in most cases by excessive temperature. Pressures with respect to bearing failure are only of secondary importance. This can be readily appreciated if the structural change which takes place in an average babbitt bearing with increase in temperature is considered. The ultimate strength of an average babbitt bearing at a temperature of 77 F is approximately 16,000 lb, at 200 F the ultimate strength drops to 9000 lb, and at 279 F it has been reduced to less than 1200 lb. It is evident then that temperature, not pressure, is the pertinent factor to consider when investigating bearing failures. The beginning of a bearing failure caused by excessive localized temperature is illustrated in (*a*) of Fig. 2. At this point in the operation, there is little more than a bright shiny spot to indicate failure. Upon continued running of this bearing, the shiny spot increased in size and eventually a minute crack was formed, as shown in (*b*). The view in (*c*) shows the same bearing after 122 hours of operation from the time the spot was first noted.

There are many causes for the development of excessive temperature in connecting rod and main bearings. One common and little considered cause is that of the introduction of foreign material, such as silica, small wear particles, or metal filings, into the lubricating system. This material is carried by the oil stream to the bearings and gradually becomes imbedded in the bearing metal, changing a precisely manufactured bearing into an excellent lapping tool. A bearing in this condition gradually wears the journal out-of-round. It has been found that this type of contamination causes wear rates as high as 0.001 in. per 100 hours of operation. A shaft worn to an out-of-round condition touches the bearing unevenly, causing local hot spots, eventually weakening the babbitt structure to an extent where even nominal pressures will result in failure. A third type of bearing failure is that of poor bonding of the bearing material to the shell proper. This is a type of failure that was once quite common, but one that has been almost eliminated. Research by bearing manufacturers has developed

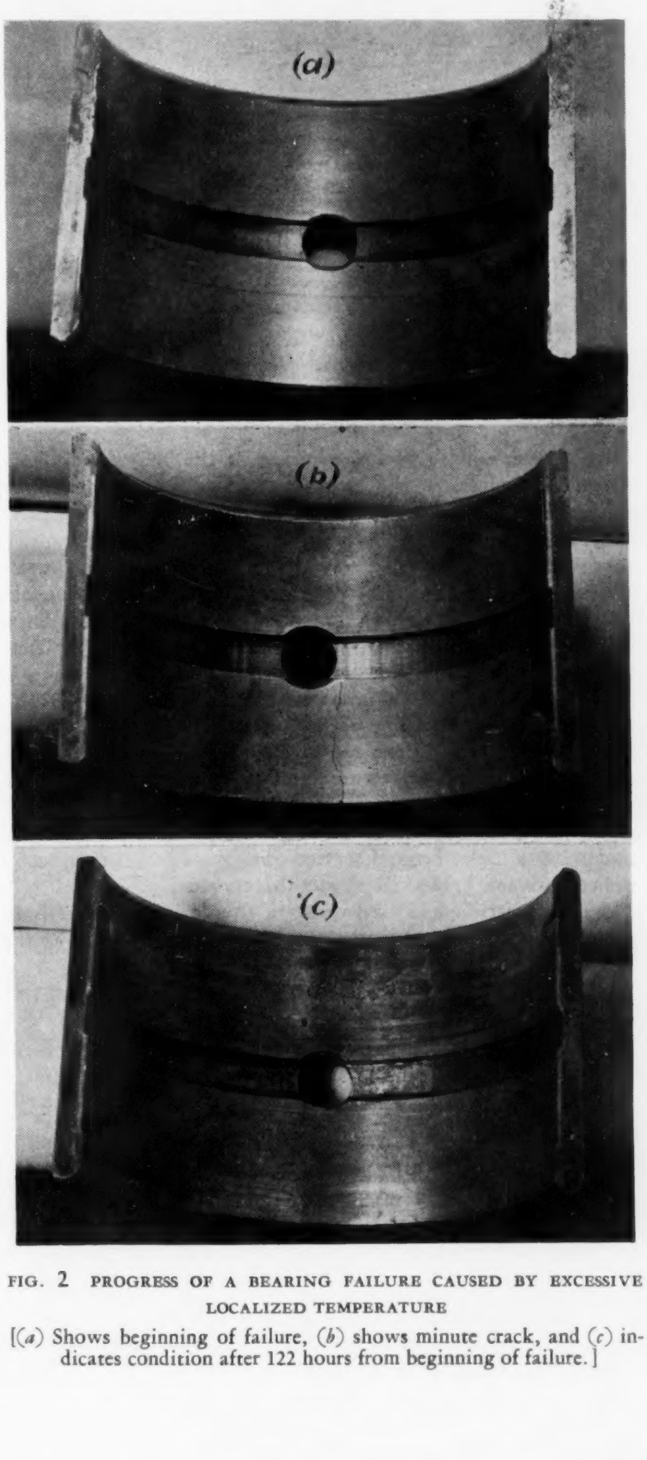

FIG. 2 PROGRESS OF A BEARING FAILURE CAUSED BY EXCESSIVE LOCALIZED TEMPERATURE

[(*a*) Shows beginning of failure, (*b*) shows minute crack, and (*c*) indicates condition after 122 hours from beginning of failure.]

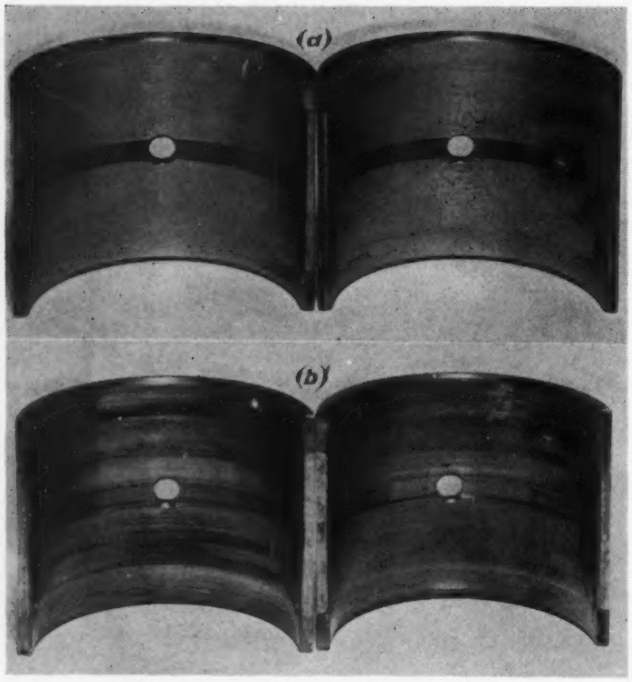

FIG. 3 EFFECT OF CHANGING AND NOT CHANGING OIL ON BEARINGS

[(*a*) A bearing after 2500 hours of operation with oil changed every 60 hours, and (*b*) another bearing run in the same engine for 500 hours without changing oil.]

methods for bonding bearing materials that have apparently solved this phase of the bearing problem. Another type of failure, and one that unfortunately is not uncommon, is that of bearing corrosion. The formation of corrosive oxidation products with the chemical decomposition of a crankcase oil sometimes results in a bearing becoming etched to a degree that will cause failure. The etching process brings about the formation of microscopic craters and cracks in the bearing surface. These become filled with minute droplets of oil, and when pressure is applied a hydraulic action is set up, forcing the oil deeper into the bearing surface and eventually breaking away sections of the bearing. The direct cause of this type of failure with normal lubricating oils is again high temperature, which is proved by the fact that practically all types of crankcase lubricants and their products of decomposition at temperatures under 200 F under normal service conditions are in themselves noncorrosive. Table 1 illustrates this conclusion.

Another little considered cause in the development of high temperatures that eventually result in bearing failure is the

TABLE 1 COMPARATIVE CORROSION OF BABBITT METAL AND CADMIUM SILVER AS A FUNCTION OF TEMPERATURE

Temp F	Oil *A*	Oil *B*	Oil *C*	Oil *D*
	Cadmium silver weight loss, mg			
209	0.0	0.0	0.2	0.0
240	0.2	37.0	1.3	7.2
270	0.6	50.3	3.7	9.6
300	0.6	27.7	22.0	23.1
330	0.6	30.3	21.0	31.7
360	2.2	9.9	20.6	12.4
	Babbitt metal weight loss, mg			
209	0.0	0.0	0.3	0.3
240	0.8	0.3	2.1	0.6
270	0.5	0.6	10.5	0.9
300	1.9	17.1	68.5	7.7
330	5.0	26.8	72.6	8.5
360	17.9	71.8	107.3	26.6

use of crankcase lubricants for extended periods beyond their limits of useful life. This practice results in increased viscosity or excessive thickening of the lubricant. A reduction in oil flow with consequent lessening of heat dissipation through this source can, and does, result in structural change in the bearing material which is conducive to bearing failure. Fig. 3 is an illustration of this type of bearing failure wherein (*a*) represents a bearing taken from an engine which has run 2500 hours with the lubricant changed every sixty hours. From the appearance of these bearing shells, there can be no doubt that many hundreds of hours of satisfactory service still remain in them. In (*b*) are shown bearing shells which had run in the same engine under identical operating conditions with respect to load, etc., except that the oil was not changed for a period of 500 operating hours. In this test every effort was made to keep foreign or carbonaceous material from being introduced or left in the system by means of effective filtration of the lubricant. In spite of these precautions, it is apparent that this bearing has already failed. In other words, the bearing problem seems to consist of the control of two main factors. First, the control of crankcase and operating temperature to a point where structural change of the bearing metal is minimized and the corrosive tendency of crankcase oils reduced to assure a sufficient safety factor; and second, the elimination, so far as possible, of the imbedding of foreign material in the bearing.

In this day and age of controversial opinion, no paper on this subject would be complete without some reference to crankcase-oil filtration or purification. The use of effective methods of filtration is of the utmost importance and, without question, has a definite place in the scheme of lubrication. It is important to point out here that the main function of a lubricating-oil filter is the removal of solid contamination from the lubricating oil. The difficulties encountered in the use of filters have been largely due to misleading advertising by various filter manufacturers. Exorbitant claims in the past have led to the use of this type of equipment as a cure-all for every conceivable trouble ever encountered in an engine or with a lubricating oil. Considering that not over ten per cent of the lubricating oil used has any lubricating value, the remaining 90 per cent acting only as a coolant and as a vehicle for "lubricity" compounds; that chemical decomposition takes place in some degree throughout the whole lubrication cycle; and that the compounds doing the work are most affected by such reactions; then the fallacy of attempting to use lubricating oils for extended periods, over and above that recommended by the engine builder who knows his engine and by the lubricant manufacturer who knows his product, is easily recognized. A filter should be considered as a means of removing solids from an oil without any beneficial refining influence.

Adsorbent or chemically active filters when used with compounded oils remove the additive agent almost immediately and are not generally accepted as being of particular value.

Too much emphasis cannot be placed upon the fact that filters are used to increase the life and efficiency of an engine, not as a means of increasing the life of the lubricant for, as described in the foregoing, lubricating-oil life is controlled by chemical reactions; the degree and severity of the reactions, governed by engine design and operation, are solely responsible for oil deterioration. The removal of contaminants, whether they result from chemical decomposition of the oil, or from outside sources, does not retard these reactions.

In conclusion, it can be said that in spite of the amazing progress made in recent years in the field of lubrication, this field of endeavor is still in its infancy. Much remains to be done by the engine builder and by the lubricant manufacturer. It is hoped that further cooperative effort will result in developments that will lead to the elimination of many present-day problems.

INDUSTRIAL-WASTE PROBLEMS *and Their* CORRECTION

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A DESCRIPTION of the status of water pollution by industrial waste should begin with a designation of the streams that are polluted and the severity with which they are affected, i.e., the location and intensity of pollution by industrial waste. For many individual areas, these facts are known with considerable accuracy and detail by local or state officials and other interested groups. A series of minute descriptions of these areas would fail to present a composite picture of stream pollution as a national problem; yet there is no common denominator by which all of the data can be made commensurate and expressible in simple quantitative units. When the deleterious effect of an industrial waste is similar to that of sanitary sewage, perspective may be gained by stating the population equivalents to the polluting industries. This concept is useful when considering the discharge of industrial wastes into sewage-treatment plants or for evaluating stream-pollution loading. However, a large part of the industrial effluents that contribute to water pollution are not expressible in these or any other common units. It is therefore necessary to abandon any attempt to present the problem in simple terms of location and intensity, even if conditions were known with complete detail for the entire country.

The industries which contribute to water pollution are well known and their location and magnitude of production are recorded by the U. S. Census of Industry. A useful preliminary view of the problem, which reveals at least potential water pollution, can be gained by examining the geographical distribution of production by these industries. In many instances the quality and volume of the receiving body of water may be so adequate that the pollution is negligible. In other instances, the waste is now being rendered harmless in private or public treatment plants. The census of waste-producing industries will fail to reveal these credits to the general picture of stream pollution. Major inaccuracies must be avoided by specifying such circumstances when they are known to exist. In spite of these limitations, much may be learned by investigating the geographical distribution of potential offenders, especially when these are so grouped as to facilitate simple generalizations about the character of the waste, the existence or possibility of treatment methods and the cost of a corrective program.

The industries which are known to have a waste-disposal problem have been assembled into the following groups: foods and beverages, textiles, chemical products, petroleum refining, iron and steel, nonferrous metals, rubber, paper, and illuminating gas.

The value of production in 1935 by these industries according to states, is shown in Table 1 and graphically in Fig. 1. The states have been arranged to correspond as nearly as possible to the sixteen drainage basins used as major units. Before interpreting the production data as indicative of existing stream pollution, it is important to note the economic significance of the industries in these groups. The total value of production was $19,424,000,000 in 1935, and the number of employees was approximately 3,000,000 persons. Employment distribution by states is shown in Fig. 2. These figures indicate the magnitude of production and employment that would be affected by any program for the abatement of stream pollution by industrial wastes, this being true regardless of any present alleviating circumstances or existing corrective treatments within these industries.

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STATUS OF WATER POLLUTION BY GROUPS OF INDUSTRIES

Foods and Beverages. Reference to Table 1 will show that the manufacture of foods and beverages accounts for the largest production value of any single group of industries selected as potentially contributing to stream pollution. These industries are also the most widely distributed, since the processing of perishable foods, such as dairy products and meat from near-by sources, is to a large extent done close to the market. Food-canning plants, on the other hand, are located at the source of supply. Therefore pollution from this industry occurs in a great number of focal centers distributed throughout the entire country. The very large meat-packing centers and locations of large canning industries, such as in California, account for the predominance of the few states that may each include more than 5 per cent of the total of food and beverage production. With these exceptions the total output valued at more than $9,000,000,000 indicates a tendency to be distributed according to concentrations of population.

For the food- and beverage-producing industries, the figures are in general agreement with the known facts of water pollution. Local dairies, abattoirs, and other plants serving a restricted area usually constitute a pollution problem of a magnitude depending upon the density of population. This is reflected in the large value of the products in the industrial centers in the New England and North Atlantic States and the industrial states of the Middle West. Exceptionally severe pollution problems are associated with the meat-packing industry in Illinois, Minnesota, and Iowa, the dairy-products industry in Minnesota, Wisconsin, and New York, and canning in California. Such industrial concentrations as these account for production figures disproportionately high with respect to the population density.

It must be borne in mind that, in a group of food- and beverage-producing industries which create such widely variable wastes as distillery slop, packing-house wastes, and cannery wash water, the pollution load represented by equal units of value of production will be very different.

Textiles. This group includes the manufacture and dyeing of textiles and textile materials, as well as the tanning and processing of leather. The concentration of the textile industry in the New England, North Atlantic, and Middle Atlantic States is clearly indicated by the value of the products. The detailed statistics especially identify Pennsylvania and New Jersey with silk and rayon, North and South Carolina with cotton, and Massachusetts with woolen textiles. Pennsylvania,

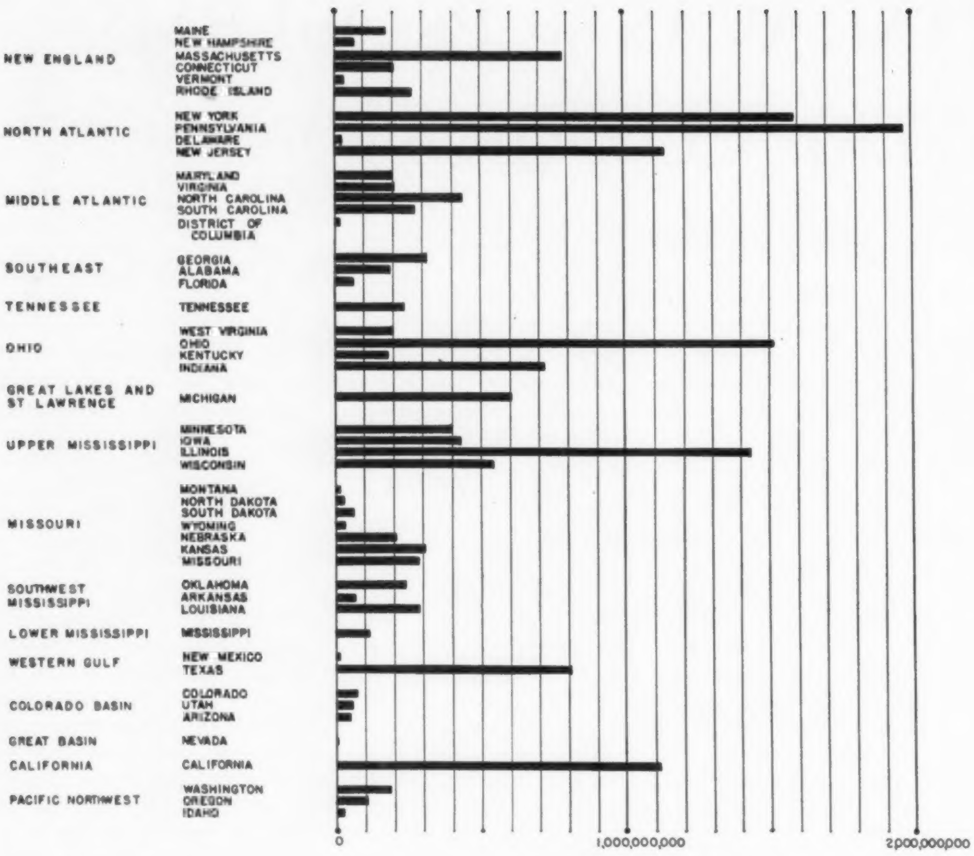

FIG. 1 ESTIMATED ANNUAL VALUE OF PRODUCTS MANUFACTURED BY INDUSTRIES, THE WASTES OF WHICH ARE CONTRIBUTING TO STREAM POLLUTION

Massachusetts, and New York, in the order named, lead the leather industry. In accordance with these facts, the major stream-pollution problems in the New England and Middle Atlantic States are related to the industries within this group. In the more highly industrialized North Atlantic States, a great number of other industrial wastes are equally as important as those from textile and leather manufacture.

Products of Chemical Processes. This group includes not only heavy chemicals, but dyes, pigments, soaps, drugs, and a great variety of products from the industries that are essentially chemical in nature. The polluting wastes are generally objectionable because of some particular toxic or corrosive property and are not directly comparable to the organic-pollution load of sanitary sewage or food-and-beverage industry wastes. The effluents from chemical industries frequently cause a high-intensity pollution over a restricted area and may entirely destroy marine life. A single illustrative example is a plant on the Middle Atlantic seaboard which, prior to the installation of recovery works, discharged the equivalent of 18 tons of sulphuric acid into tidal waters every day. These industries are concentrated in New York, New Jersey, and Pennsylvania and in the industrial area bordering on the southern and eastern shores of Lake Michigan. There are also scattered centers near sources of raw materials, such as in Tennessee, West Virginia, Louisiana, and a great number of other localities.

Petroleum Refining. Centers of oil refining are usually characterized by water-pollution by-products from various stages of the processes, as well as wash waters and treating reagents, which form a significant addition to the total pollution loading of the region. These centers are clearly brought out in the production figures of Table 1. In order of importance they are Texas, California, Pennsylvania, New Jersey, Indiana, and Oklahoma. Several other states possess refining industries of large magnitude.

Ferrous Metals. The iron-and-steel industry is dominated by Pennsylvania, Ohio, Indiana, and Illinois, with smaller units in a number of other states. Many individual plants may not be reflected in the table because no figures were reported. This is especially true of the New England and Middle Atlantic States, where the industry constitutes a water-pollution problem in certain localities. However, the relative magnitude of the pollution is probably reflected in the distribution of production.

Nonferrous Metals. This group of industries, including smelting, refining, and processing of nonferrous metals and alloys, but not including mining, is responsible for scattered instances of pollution of high intensity because of pickling acids, plating chemicals, and similar materials. Most of the activity is centered in the industrial North Atlantic States and in the Chicago District, but smelting and refining in the Colorado Basin is a regional pollution problem of some severity.

Rubber Manufacture. As the production figures indicate, almost 70 per cent of the rubber industry is concentrated in Ohio. The waste problem in this industry is almost entirely due to the large volumes of water used in reclaiming old rubber tires and other articles from which foreign material must be removed. The pollution from this cause is a negligible fraction of the entire load except in certain parts of Ohio.

Paper Manufacture. In the production of paper pulp, the most important states are Washington, Maine, Wisconsin, Virginia, and New York. In the manufacture of paper from the finished pulp, New York, Wisconsin, Michigan, Ohio, Pennsylvania, Maine, and Massachusetts, in the order named, lead the industry. As the production figures show, there are many widely scattered centers of much less importance, particularly in the strawboard and craft group. These frequently cause pollution which presents a difficult problem. Since the figures in Table 1 are for 1935, they do not reflect the recent rapid growth of the industry in the Southern States. Many new mills have been built to take advantage of raw materials which are being processed by new methods. However, in a number of instances, the new plants have anticipated the waste-disposal problem and have installed elaborate and costly treatment equipment. The occurrence of water pollution by this industry therefore follows more nearly the production figures for the older mills, although credit should not be withheld when the latter have installed corrective treatment.

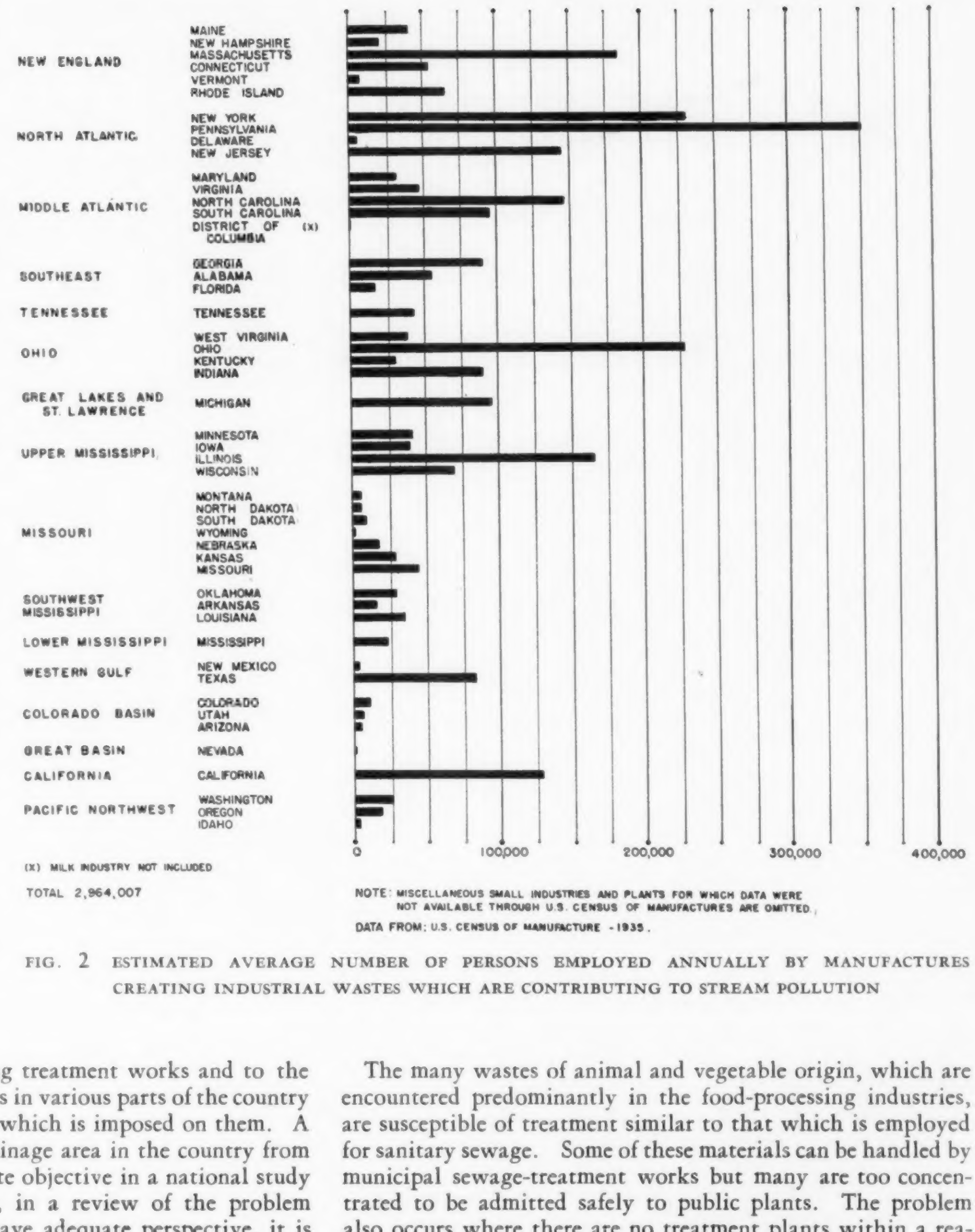

FIG. 2 ESTIMATED AVERAGE NUMBER OF PERSONS EMPLOYED ANNUALLY BY MANUFACTURES CREATING INDUSTRIAL WASTES WHICH ARE CONTRIBUTING TO STREAM POLLUTION

Gas Manufacture. It has long been recognized that the manufacture of coal gas and water gas produces polluting effluents which are highly undesirable. On the other hand, the industry has been alert to the situation and has succeeded greatly in mitigating some of the worst conditions. Since the production of gas follows concentrations of industry and population (except where natural gas is available) there are a great number of units scattered throughout the country. Domination in size will only be found near high concentrations of population, as in New York and in the New England States. The production figures in Table 1 are fragmentary and certainly omit values for many states. However, they are sufficient to emphasize the fact that a water-pollution problem from the manufacture of gas exists in the industrial New England and North Atlantic States and in parts of the Middle West.

STATUS OF WATER POLLUTION IN DRAINAGE AREAS

While the geographical distribution of industries which contribute to water pollution may give a fair picture of the actual occurrence of the polluting materials, attention should also be given to existing treatment works and to the relative abilities of surface waters in various parts of the country to handle the pollution loading which is imposed on them. A minute examination of each drainage area in the country from this point of view is the ultimate objective in a national study of water pollution. However, in a review of the problem which is sufficiently brief to have adequate perspective, it is only possible to indicate very generally the status of pollution in the major areas.

AVAILABILITY OF METHODS OF TREATMENT FOR INDUSTRIAL WASTES—GENERAL PRINCIPLES

Treatment works for industrial wastes vary widely both as to the structures required and the principles of operation. It is obviously impossible to devise any standardized form of treatment which satisfactorily and economically might produce the desired results for all industries. It is true, of course, that practically all liquid wastes might be evaporated and moisture thereby eliminated, until the solid content of the residue permitted of disposal elsewhere than in the streams. To attempt any such elaborate program would be prohibitive in cost and otherwise impractical. On the other hand, in the present state of the arts, this is the only method of treatment which will produce a harmless effluent from certain wastes. It is the opinion of many investigators that distillery waste comes within that category and others may also be so classified.

The many wastes of animal and vegetable origin, which are encountered predominantly in the food-processing industries, are susceptible of treatment similar to that which is employed for sanitary sewage. Some of these materials can be handled by municipal sewage-treatment works but many are too concentrated to be admitted safely to public plants. The problem also occurs where there are no treatment plants within a reasonable distance. Moreover, the physical nature of the facilities and the nature of the biological or chemical process must often be adapted to the characteristics of the specific wastes. Industries in which this general group of methods may be workable are food canning, dairying, tanning, the fermentation industries, beverage manufacturing, and others.

There are many industrial effluents, the objectionable characteristics of which are due to suspended matter or to dissolved solids, which can be precipitated with or without the use of chemicals. These wastes are susceptible to settling and filtering.

The processes are essentially similar to those used in the clarification of water by filtration. Through many years of sanitary-engineering experience in water purification, a useful basic knowledge has been established of precipitating reagents, design of treatment works, and construction and operating costs. In this group might be classified certain textile- and paper-mill wastes, gas-plant wastes, paints and pigments, and effluents from numerous chemical and metallurgical processes.

The three methods discussed, namely, evaporation, biological

TABLE 1 ESTIMATED VALUE OF PRODUCTS MANUFACTURED BY SELECTED INDUSTRIES FROM WHICH WASTES MAY CONTRIBUTE TO WATER POLLUTION

(Data compiled from U. S. Census of Manufactures, 1935)

INDUSTRIAL GROUP

	FOODS & BEVERAGES	CHEMICAL PROCESSES	GAS MFG.	PETROLEUM REFINING	TEXTILES	FERROUS METALS	NON FERROUS METALS	PAPER MFG.	RUBBER MFG.	STATE TOTAL
	VALUE OF PRODUCTS REPORTED IN THOUSANDS OF DOLLARS									
NEW ENGLAND										
MAINE	39,655		1,541		67,907			76,259		185,362
MASSACHUSETTS	207,692	37,707	26,076		445,564		10,541	52,684		780,264
NEW HAMPSHIRE	13,263		1,565		49,560			14,124		78,512
CONNECTICUT	52,532	10,698	5,401		99,330		15,813	10,034	9,827	203,655
VERMONT	13,433		623		13,130			5,632		32,818
RHODE ISLAND	26,209	5,060			224,168		2,441	10,138	10,139	278,155
TOTAL	352,804	53,465	35,206		899,659		28,795	168,871	19,966	1,558,766
NORTH ATLANTIC										
NEW YORK	813,964	286,922	97,219		166,815	87,947	26,692	94,492	22,019	1,596,070
PENNSYLVANIA	594,508	120,883		204,466	294,849	630,514	35,625	62,503	8,461	1,951,809
NEW JERSEY	260,633	221,907		157,863	175,023	24,510	189,500	30,690	37,803	1,097,929
DELAWARE	12,048	620			11,790			1,267		25,725
TOTAL	1,681,153	630,332	97,219	362,329	648,477	742,971	251,817	188,952	68,283	4,671,533
MIDDLE ATLANTIC										
MARYLAND	138,513	24,435		272	10,453		1,140	9,211	1,328	182,352
VIRGINIA	91,548	25,903	4,372		44,266		3,311	34,293		203,693
NO. CAROLINA	112,501	2,595	2,351		320,734					438,181
SO. CAROLINA	62,126	99	1,230		212,285					275,740
TOTAL	401,688	53,032	7,953	272	587,738		4,451	43,504	1,328	1,099,966
SOUTHEASTERN										
GEORGIA	147,196	3,765	861		167,329					319,251
ALABAMA	99,550		104		18,339	10,383				128,376
FLORIDA	94,042	962	3,806							98,810
TOTAL	340,788	4,727	4,871		185,668	10,383				546,437
TENNESSEE										
TENNESSEE	164,508	33,564			28,298			11,273		237,643
OHIO VALLEY										
W. VIRGINIA	59,643	39,654		10,305	6,438	83,353		4,118		203,511
OHIO	402,268	122,663		68,351	18,004	514,317	8,185	64,256	324,646	1,522,690
KENTUCKY	144,788	8,578		15,787	6,540				40	175,733
INDIANA	287,520	21,149	10,288	149,788	8,454	250,460	5,407	11,004	4,354	748,424
TOTAL	894,219	192,044	10,288	244,231	39,436	848,130	13,592	79,378	329,040	2,650,358
GREAT LAKES										
MICHIGAN	276,443	99,684	27,276		29,765	96,813	2,234	75,792	5,618	206,625
UPPER MISS.										
MINNESOTA	370,445	8,574			2,938		406	19,675		402,038
IOWA	415,843	7,304	4,673				64			427,884
WISCONSIN	379,084	12,938	12,853		35,287	11,429	454	93,876	2,206	548,127
ILLINOIS	894,523	168,397		80,797	45,893	176,482	36,795	24,443	8,575	1,435,905
TOTAL	2,059,895	197,213	17,526	80,797	84,118	187,911	37,719	137,994	10,781	2,813,954
MISSOURI										
MONTANA	30,528			7,191						37,719
NO. DAKOTA	31,841									31,841
SO. DAKOTA	61,272									61,277
WYOMING	7,764			24,654						32,418
NEBRASKA	178,190	744		173			35			179,142
KANSAS	228,541	1,027		82,010						311,578
MISSOURI	277,280	33,814			2,014		324		3,843	317,275
TOTAL	815,421	35,585		114,028	2,014		359		3,843	971,250
SOUTHWEST MISS.										
OKLAHOMA	127,843	612		106,689			5,271			240,415
ARKANSAS	55,769			10,476	1,396					67,641
LOUISIANA	160,965	18,101		82,441	638			31,989		294,134
TOTAL	344,577	18,713		199,606	2,034		5,271	31,989		602,190
LOWER MISS.										
MISSISSIPPI	108,228	2,317			5,596					116,141
WESTERN GULF										
NEW MEXICO	12,058			2,366						14,424
TEXAS	356,900	7,483		437,790	8,970		90		284	811,517
TOTAL	368,958	7,483		440,156	8,970		90		284	825,941
COLORADO BASIN										
COLORADO	74,423	1,027	96							75,546
UTAH	39,783						14,145			53,928
ARIZONA	25,244		138				30,126			55,508
TOTAL	139,450	1,027	234				44,271			184,982
GREAT BASIN										
NEVADA	2,859									2,859
CALIFORNIA										
CALIFORNIA	651,782	96,289		265,386	11,185	26,539	8,028	13,502	40,344	1,115,055
PACIFIC N. WEST										
WASHINGTON	123,735	4,561	3,010					53,224	88	184,618
OREGON	77,953	1,332			6,203	1,162	35	18,240		104,925
IDAHO	26,435		168							26,603
TOTAL	228,123	5,893	3,178		6,203	1,162	35	71,464	88	316,146
SUB-TOTAL	8,830,896	1,433,368	203,751	1,706,805	2,539,161	1,902,909	396,662	822,719	479,575	18,315,846
OTHER STATES	288,252	60,855	139,764	115,497	212,312	3,219	59,954		16	879,869
GRAND TOTAL	9,119,148	1,494,223	343,515	1,822,302	2,751,473	1,906,128	456,616	822,719	479,591	19,195,715

ANTHRACITE COAL VALUE FOR PENN VIRGINIA ARKANSAS COLORADO NEW MEXICO & WASHINGTON — 228,639

GRAND TOTAL — 19,424,354

TABLE 2 ESTIMATED COST OF INDUSTRIAL-WASTE TREATMENT IN THE UNITED STATES, BASED ON COMMODITY PRODUCTION REPORTED IN U. S. CENSUS OF MANUFACTURES, 1935

Food	$205,400,000
Paper	129,031,000
Textiles	54,000,000
Petroleum	30,000,000
Nonferrous metals	21,657,000
Ferrous metals	20,000,000
Chemicals	28,300,000
Gas manufacturing	5,034,000
Rubber	1,000,000
Anthracite coal	40,000,000
Miscellaneous	100,000,000
Added amount for contingencies	100,000,000
Total for United States	$734,422,000

NOTE: This does not include disposal of oil-field-brine waste or sealing of bituminous coal mines.

decomposition, and precipitation, cover, by far, the greater majority of the existing industrial-waste-treatment methods which are available. There is a fourth general category in which industrial wastes are converted into marketable products. The possibility of recovering valuable products is a question concerning which there has been a great deal of controversy. Many extensive and misinformed statements have been made on the subject, which were based upon wishful thinking rather than upon factual data. It is true that remarkable results have been accomplished in certain units of various industries, such as the production of activated carbon, alcohol, and vanillin from paper-mill wastes, copperas from steel-mill pickling liquors and pigment-plant wastes, and many others which stimulate the imagination as to what might be accomplished in the future.

However, it is generally true that the useful products made from a small fraction of the total available volume of a certain

TABLE 3 TREATMENT COST DISTRIBUTED BY INDUSTRY AND STATES

INDUSTRIAL GROUP

TREATMENT COST REPORTED IN THOUSANDS OF DOLLARS

	FOODS & BEVERAGES	CHEMICAL PROCESSES	GAS MFG.	PETROLEUM REFINING	TEXTILES	FERROUS METALS	NON FERROUS METALS	PAPER MFG.	RUBBER MFG.	STATE TOTAL
NEW ENGLAND										
MAINE	588	12	22		1,109			13,891		15,622
MASSACHUSETTS	1,894	2,315	375		8,108	209	243	2,665	72	15,981
NEW HAMPSHIRE	175	11	23		874			5,925		7,008
CONNECTICUT	729	138	78		1,755	155	2,494	927	28	6,304
VERMONT	554	10	*		231			508		1,303
RHODE ISLAND	522	210			3,953		141		11	4,837
TOTAL	4,562	2,696	498		16,030	364	2,878	23,916	111	51,055
NORTH ATLANTIC										
NEW YORK	16,608	4,195	1,409		3,887	1,254	1,870	11,655	17	40,895
PENNSYLVANIA	10,711	2,621		3,321	5,965	5,748	663	5,967	26	35,022
NEW JERSEY	5,634	4,455		2,626	3,369	290	5,146	1,772	30	23,322
DELAWARE	324	33			3,011	27		519		3,914
TOTAL	33,277	11,304	1,409	5,947	16,232	7,319	7,679	19,913	73	103,153
MIDDLE ATLANTIC										
MARYLAND	5,122	287			190	462	426	768		7,255
VIRGINIA	1,186	250	63		1,642	510		5,777		9,428
NO. CAROLINA	958	348	34		5,671			2,022		9,033
SO. CAROLINA	649	121	18		3,743			155		4,686
TOTAL	7,915	1,006	115		11,246	972	426	8,772		30,402
SOUTHEASTERN										
GEORGIA	1,425	172	14		169		10	365		2,155
ALABAMA	869	99	*		1,495	641	*	2,886		5,990
FLORIDA	1,354	54	55					2,808		4,271
TOTAL	3,648	325	69		1,664	641	10	6,059		12,416
TENNESSEE										
TENNESSEE	2,095	649			1,229	255	419	911		5,558
OHIO VALLEY										
W. VIRGINIA	1,161	568	35	165	125	745	13	763		3,541
OHIO	9,617	1,526		1,163	653	3,868	1,023	4,202	532	22,621
KENTUCKY	5,392	74		252	121	263	13		*	6,115
INDIANA	8,668	420	148	2,416	154	2,069	257	1,534	*	15,667
TOTAL	24,838	2,588	183	3,996	1,053	6,945	1,306	6,499	532	47,940
GREAT LAKES										
MICHIGAN	16,629	1,049	393	265	559	825	1,932	8,002	*	29,654
UPPER MISS.										
MINNESOTA	8,834	85			51	282	43	3,470	64	12,829
IOWA	10,943	129	67				*	190		11,329
WISCONSIN	10,688	89	185		654	209	298	15,116	64	27,303
ILLINOIS	15,732	2,764		1,323	854	1,290	1,019	1,974	11	24,967
TOTAL	46,197	3,067	252	1,323	1,559	1,781	1,360	20,750	139	76,428
MISSOURI										
MONTANA	946			115			883			1,944
NO. DAKOTA	667									667
SO. DAKOTA	1,091	20								1,111
WYOMING	538			394			*			932
NEBRASKA	3,400	20		*			28			3,448
KANSAS	3,326	182		1,312			28	144		4,992
MISSOURI	6,947	260			38	81	185	87	*	7,598
TOTAL	16,915	482		1,821	38	81	1,124	231		20,692
SOUTHWEST MISS.										
OKLAHOMA	1,392	16		1,837			15			3,260
ARKANSAS	1,564			168	25		*	1,479		3,236
LOUISIANA	6,252	152		1,319	10			9,070		16,803
TOTAL	9,208	168		3,324	35		15	10,549		23,299
LOWER MISS										
MISSISSIPPI	602				99			1,696		2,397
WESTERN GULF										
NEW MEXICO	81			38			28			147
TEXAS	5,485	106		7,105	159		890	496		14,241
TOTAL	5,566	106		7,143	159		918	496		14,388
COLORADO BASIN										
COLORADO	2,595	30				336	83	48		3,092
UTAH	1,146					255	460			1,861
ARIZONA	141		*				864			1,005
TOTAL	3,882	30				591	1,407	48		5,958
GREAT BASIN										
NEVADA	53						419			472
CALIFORNIA										
CALIFORNIA	14,722	1,214		4,286	210		158	855	77	21,522
PACIFIC N.WEST										
WASHINGTON	3,688	190	43			27	442	15,880		20,270
OREGON	1,171	18			110		13	4,504		5,816
IDAHO	971	10	*				34			1,015
TOTAL	5,830	218	43		110	27	489	20,384		27,101
SUB-TOTAL	195,939	24,902	2,962	28,105	50,223	19,801	20,540	129,031	932	472,435
OTHER STATES	9,461	3,398	2,072	1,895	3,777	199	1,117		68	21,987
GRAND TOTAL	205,400	28,300	5,034	30,000	54,000	20,000	21,657	129,031	1,000	494,422

* TREATMENT FOR INDUSTRIES ARE CARRIED IN OTHER STATE TOTALS AT A MINIMUM TOTAL OF 10,000 DOLLARS EACH.

ANTHRACITE COAL TREATMENT COST FOR ENTIRE COUNTRY	40,000
MISCELANEOUS INDUSTRIES NOT LISTED ABOVE	100,000
ADDED AMOUNT FOR CONTINGENCIES	100,000
GRAND TOTAL	734,422

industrial waste would satisfy the entire market for the product. It would be impossible to increase the consumption sufficiently to justify widespread adoption of this method of disposing of the wastes. While credit should be given to the accomplishments of industry in salvaging these waste materials, and research in this field should be stimulated, it must be recognized that profitable recovery is exceptionally rare and that waste treatment is almost invariably a costly burden upon industries.

COST OF INDUSTRIAL-WASTE TREATMENT

An accurate estimate of the cost of industrial-waste treatment throughout the United States is impossible of achievement, because there is a lack of accurate information on the cost of installation and operation of the many types of plants required for the various materials which are encountered.

In some industries there are rather complete data from which unit costs may be established. This is the case, for instance,

TABLE 4 STATUS OF BITUMINOUS-MINE SEALING IN EASTERN UNITED STATES, AS OF JANUARY, 1938

	Number of mines	Number of tons per year: Total acid produced	Number of tons per year: Reduction accomplished	Cost
Original estimate:				
Total mines	27,867	2,701,345	....	....
Active mines	8,121	1,247,953	....	....
Marginal mines	3,424	253,987	....	....
Abandoned mines	16,322	1,199,405	....	....
Work completed:				
Sealed mines	4,075	700,000	600,000	$4,751,000
Work in progress:				
Sealed mines	500	133,000	100,000	$1,744,000

NOTE: Work completed and in progress does not include the states of Alabama, Arizona, Illinois, and Tennessee.

The estimated cost of completing this work by continuing on the same basis is $7,000,000. To control the acid from worked-out sections of operating mines would require an additional $5,000,000.

with respect to the treatment of waste from certain food-processing industries, such as vegetable canneries, dairies, abattoirs, etc. Likewise, fairly reliable cost data are obtainable for treating tannery wastes and certain paper-mill wastes, evaporating distillery slop, sealing coal mines to prevent formation of sulphuric acid, and other corrective measures. However, even when such data are obtainable, their use requires experience and judgment because of the varying concentrations of wastes which are encountered, the location of the plant and the degree of purification which is required under the local conditions.

The accompanying estimates have been based on cost data applicable to production units for which reliable statistics are available. This method of approach facilitates a rapid assembly of information but involves the erroneous assumption that an equal degree of treatment is invariably necessary for a given industrial waste. A universal estimate for complete treatment would undoubtedly be very much too high and, to compensate for this, the unit costs have been reduced to amounts which should provide the necessary degree of treatment for all varieties of materials to which the costs are applied.

Estimates for the cost of a construction program of industrial-waste-treatment plants have been compiled for the volume of production indicated by the 1935 Census of Manufactures. Since that year there has been considerable progress in the alleviation of stream pollution, especially in certain states where great activity has followed the enactment of new legislation. On the other hand, many new industrial units contributing seriously polluting effluents have been built, such as the numerous paper mills throughout the South. In general the increase in industrial activity has also tended to make the pollution problem more serious. In view of the compensating effect of changes since 1935, the estimate is believed to be a fair approximation of present requirements.

The estimate for the total cost of construction for the United States is $734,000,000. This does not include the disposal of oil-field brines or the sealing of bituminous-coal mines, for reasons explained later. Table 2 shows the cost for various groups of industries. Table 3 indicates the total cost distribution according to states.

POLLUTION BY OIL-FIELD BRINES

It will be noted that, in the total estimate of the cost of industrial-waste treatment on a nation-wide basis, the author has omitted the cost of eliminating oil-field-brine waste, which is developed in the production of crude oil. This omission has been made deliberately. No estimate of the total volume of oil-field brine can be made on the basis of existing records. Further, there is no definite means of disposal yet developed which is universally adaptable to various operating areas. According to most conservative estimates, the cost of disposal is such a large figure that its inclusion in the general summation of costs would present an unbalanced picture of the general problem. A conservative estimate of this cost is at least $100,000,000 and it is conceivable that this figure might be doubled.

It is the author's opinion that each problem of brine disposal from the oil fields should be treated as a separate project and segregated from the general problem of stream pollution from miscellaneous manufacturing processes.

MINE DRAINAGE AND CULM FROM BITUMINOUS- AND ANTHRACITE-COAL FIELDS—MINE SEALING

Much progress has been made in minimizing water pollution resulting from mine drainage. The estimated number of various grades of mines contributing to stream pollution and the number of mines so far sealed is summarized in Table 4. In this table, it will be noted that the estimated reduction in the amount of sulphuric acid discharged from these mines amounted to 600,000 tons annually. Such estimates should not be considered as strictly accurate quantitative figures, since they are based on 100 per cent acid in terms of calcium carbonate and an assumed efficiency of 100 per cent. The estimated reduction in the amount of acid is probably greater than the actual accomplishments and should be discounted by possibly 25 or 30 per cent. Notwithstanding variations in the estimate, the coal-mine-sealing program has been, in general, ably directed. The funds expended have materially reduced the gross water-pollution problem in the areas affected by such wastes.

It is impossible to make accurate estimates of the extent to which there has been a reduction in the stream-pollution loading of such wastes, because the volume and concentration of acids produced vary widely with seasonal conditions. It is believed, however, that the ultimate beneficial effects of mine sealing will not be fully attained at first, but that conditions will gradually improve with time because of the silting up of channels, which will occur as a result of restricting the flow rates of the mine waters.

An estimate of the amount of federal funds which should be further allocated to this work depends on the degree of complete sealing which may be done. A program of elaborate sealing in which all openings were closed would be unnecessarily costly and impractical. However, there is still need for continuation of this work along the lines which have been followed during the last two years. It has been estimated that $12,000,000 can wisely be expended for work of this kind.

ANTHRACITE-MINE WASTES

Consideration has been given to the extent of water pollution by culm wastes, created in the mining of anthracite coal. There is but a small fund of accurate or specific data concerning either the extent of the problem or the value upon which to base a cost estimate for correcting this type of pollution. For this reason it has been necessary to evaluate the cost of corrective treatment solely from a general knowledge of the existing condition. This, however, is restricted to a limited region. On this basis it has been estimated that, by an expenditure of $40,000,000 for treating facilities, gross water pollution now extant may be prevented. Such an expenditure, although it would probably not eliminate completely all wastes of this kind, could be wisely spent to control the gross pollution now occurring in some areas.

The suggested expenditures for this purpose are not included in the figure of $100,000,000 allocated to the correction of miscellaneous wastes not specifically considered elsewhere in estimated figures for other industries.

CONCLUSION

To summarize briefly the results of the author's recent investigation, the problem of water pollution by industrial wastes involves most of the industries of major economic importance. Eliminating the treatment of oil-well brines in the producing fields and the sealing of mines to prevent acid wastes, it is a reasonable prediction that the cost of the installation of treatment facilities will probably be in excess of $734,000,000. If the cost of treating oil-well brines and mine drainage is added, the total amount that would be involved will greatly exceed this figure.

Although no claims are made for strict accuracy of the figuers cited, it is believed that the fundamental data and their interpretation are sufficiently correct to form the basis of a closely approximate estimate.

Factors in

SUGAR-CANE MILLING

By ARTHUR G. KELLER

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THE MANUFACTURE of sugar from cane is an industry which over a period of some fifteen hundred years has evolved from crude one-man affairs to plants which handle as much as ten thousand tons of cane per day. It is interesting to note that plants representing practically all stages of evolution are in operation in various parts of the world even today.

The first and principal step in sugar manufacture is the extraction of the sugar-bearing juice from the cane. This operation, usually termed milling, is accomplished by squeezing the cane between some type of rollers. The development of the modern three-roller mill is usually dated from 1871, in which year patents were issued to Rousselot on a three-roller cane mill which with a few minor changes continues to be the principal piece of milling equipment to this day.

Fig. 1 shows an elevation of the Rousselot mill on which patents were granted in 1871. Fig. 2 shows the conventional

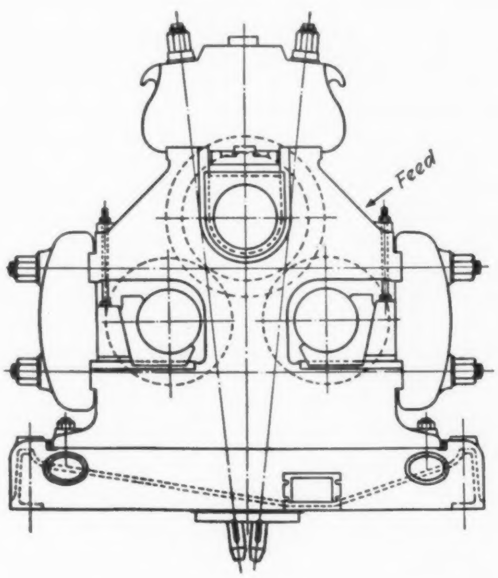

FIG. 1 ROUSSELOT MILL HOUSING OF 1871

type of present-day mill. This mill consists of three horizontal cylinders, and any two coacting units are caused to rotate in opposite directions by means of suitable gearing. It is characterized by the location of the centers of the three rollers at the apexes of an approximate isosceles triangle. The rollers are designated as the feed roll, the top roll, and the discharge or bagasse roll. Bridging the gap between the feed and discharge rolls is a well-fitted iron beam termed the trash turner or turn plate. The roll bearings are carried in heavy iron frames termed housings. Their design is such that rolls can be readily removed. Wedges, screws, or trunnions are provided for adjusting the positions of the rollers with respect to one another. In order to compensate for irregularities in feed, to permit of the application of greater pressure to the bagasse, and as a safety measure in case tramp iron enters the mill, the top roll is arranged to lift under a predetermined pressure. Pressure regulation is effected by a hydraulic-ram assembly mounted over the top-roll journals.

PROBLEMS ENCOUNTERED IN MILL OPERATION

The problems encountered in mill operation are many. They may for convenience be divided into two groups (*a*) problems

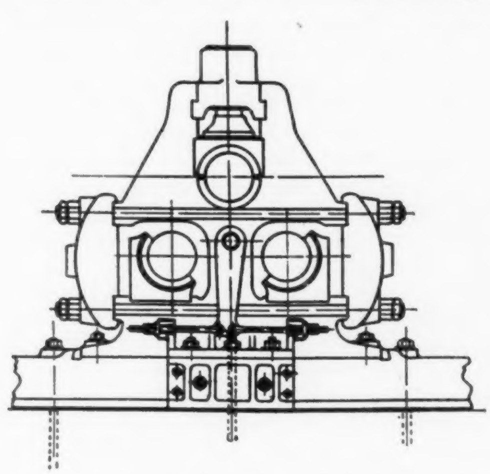

FIG. 2 MODERN TYPE OF ROUSSELOT HOUSING

of design and (*b*) operating problems. It may be argued with some justification that operating problems are design problems too, for if the design were flawless the machine should function perfectly.

The modernized Rousselot type mill, while universally employed, is by no means without serious deficiencies. For one thing, the effective pressure between the top roll and the feed roll is usually considerably less than that between this roll and the bagasse roll. It is necessary to have a large opening and a lower pressure between the top and feed rolls than between the top and bagasse roll in order to insure satisfactory feeding of the mill. In Fig. 3 there is presented the force diagrams of the conventional Rousselot type mill. It will be noted that there is a horizontal component of considerable magnitude which acts to force the top-roll bearing against the side of its guides and thus restrict its free movement in a vertical plane. The effects of this side thrust are well known to mill operators and are conceded to be quite detrimental to efficient operation. Numerous designs have been evolved to reduce this trouble, but only one, the triangular housing, has met with any degree of acceptance. This type is illustrated in Fig. 4. Note that the axes of the bottom rollers are moved closer to-

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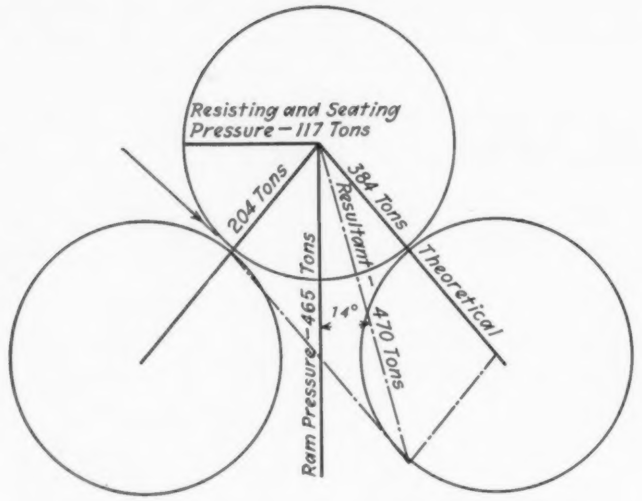

FIG. 3 PRESSURE DIAGRAM OF ROUSSELOT MILL

gether, thus reducing the included angle they make with the top roll, and lowering the value of the horizontal component.

Another design, calculated to reduce the horizontal component to zero, is the inclined type of housing which is illustrated in Fig. 5. This design is not new but it has recently been revived and for that reason is included here. The housing is inclined at the angle which the resultant of the forces acting on the mills makes with the vertical under ordinary operating conditions. The value used is necessarily an approximation since the angle shifts as operating conditions change. The fundamental weakness in the idea is that none of the forces nor their resultant can be measured, with the single exception of the vertical component representing the hydraulic head on the top of the roll.

Recognition of the fact that the application of pressure to the top roll in the conventional mill was the cause of numerous difficulties, has resulted in the development of several designs in which two rolls are independently pressured instead of one as formerly. The design illustrated in Fig. 6 is the only one of the group mentioned that seems to have gone further than the drawing-board stage. A unit of this type, called the constant-pressure mill, is in operation in Louisiana.

Since mills are quite expensive and in addition quite long-lived, the operator is faced with the problem of making the best of what he has. New designs, while interesting, seldom offer sufficient promise to warrant replacement of good existing mills. The operator's problems are numerous and varied. His troubles are aggravated by the paucity of reliable data on mill performance. The reasons for this lack of knowledge and advancement are many. Among others might be listed the numerous variables involved, the limited flexibility of commercial installations, and the expense attendant on interruptions of the operations which might be caused by experiments. A description of the milling process will simplify the explanation of the variables involved.

PRESENT-DAY MILLING OPERATION

The milling operation as carried out in present-day plants consists of several steps. The first is the preparation of the cane for milling. Sugar cane is fed to the mills as a tangled mass of stalks which contains considerably more voids than cane. This bulk must be reduced to facilitate feeding. It is also advantageous at this stage to destroy the cylindrical structure of the cane stalk since this aids in compacting the mass and reduces the amount of power needed in the squeezing operations which are to follow. Cane preparation is usually effected by revolving knives, hammer mills, two-roll mills termed crushers, or more commonly, by a combination of two or more of these pieces of equipment. The second step in cane milling is the extraction of the sugar-bearing juices from the cane by squeezing it between the mill rollers. Repeated squeezings combined with the application of water between pressings is necessary to obtain reasonably complete removal of sugar from the cane or bagasse as the exhausted residue is termed. The milling plant proper usually consists of a two-roller mill followed by from two to seven three-roller mills in tandem. Fig. 7 indicates graphically the stages of extraction involved in a twelve-roll tandem, preceded by a two-roll crusher. The proportions approximate averages in certain of the tropical cane-sugar countries. It should be borne in mind that in routine practice these proportions vary widely. Note that the juices extracted by the third and fourth mills are returned in cycles of maceration. Obviously variations at one stage affect the entire cycle and, as a matter of fact, the entire milling operation comprises a series of varying cycles.

The aim of the mill operator is the extraction of sucrose at a minimum unit cost. As criteria of the quality of his work he considers sucrose extracted as percentage of sucrose in cane, tons of cane ground per unit of time, amount of maceration water used as percentage of weight of cane, and the fuel quality of the bagasse produced.

FACTORS AFFECTING ATTAINMENT OF AIM

It will be the purpose of this paper to consider the principal factors which affect the attainment of the aim just mentioned. As factor number one, there is the cane itself. The diameter of the stalk, its fiber content, and its physical condition affect mill operation possibly more than any other single thing. Fiber content in cane may vary from 8 to 18 per cent. Louisiana

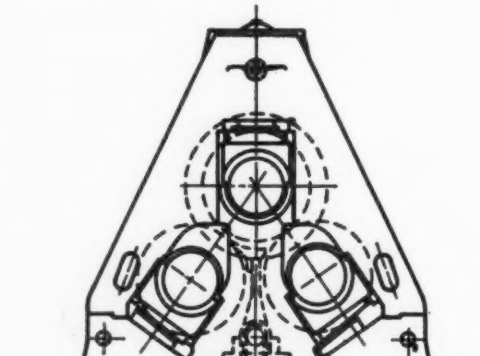

FIG. 4 TRIANGULAR HOUSING, SQUIER PATENT

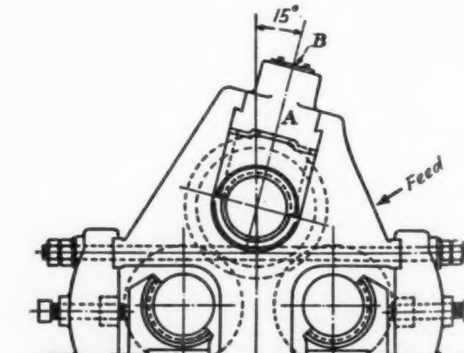

FIG. 5 HEDEMANN INCLINED TYPE OF HOUSING

average is about 14 per cent. Since fiber is relatively incompressible, an increase of this constituent in the cane means a reduction in capacity of the mills. It is the introduction of small-barreled high-fiber canes during recent years that has aroused most interest in means of improving mill operation. This particular factor is one over which the operator has little control. He must change his equipment and methods to suit the raw material.

The second factor to be considered is the method of preparation of cane for the mills. As previously mentioned, the usual preparatory equipment consists of cane knives, hammer mill, crusher, or some combination of these. Cane knives serve principally to even out and compact the mass of cane being fed to the mill. Manufacturers and operators are fairly well agreed that their use increases the capacity of a given tandem from 5 to 25 per cent depending on the kind of cane being ground. They usually cause a small but measurable increase in sucrose extraction. This last probably results from the more uniform feeding of the mills which the knives make possible. Hammer mills or shredders as they are termed in the sugar industry have been in use for some twenty years. The general concensus of opinion seems to be that shredders are an aid to better milling but to what extent it is difficult to say. By completing the disintegration of the cane they make possible the more efficient use of maceration and relieve the mills of some of their work. There is some question in Louisiana as to whether the shredder should precede or follow the crusher.

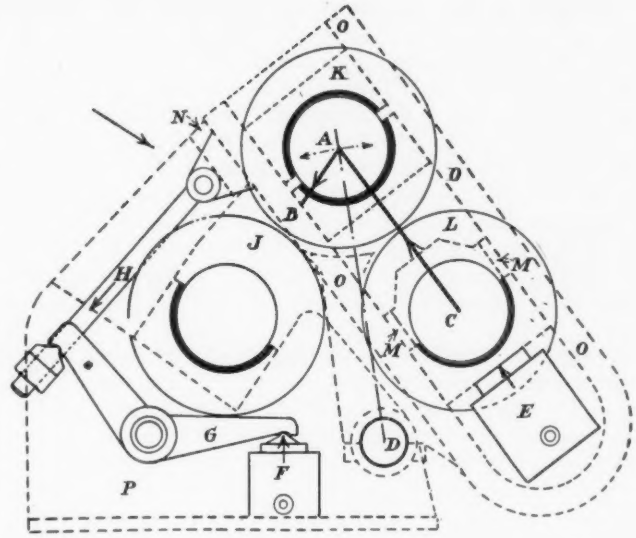

FIG. 6 DIAGRAM OF CONSTANT-PRESSURE CANE MILL

A–B feed-roll pressure, independently adjustable
A–C discharge-roll pressure, independently adjustable
D high-pressure housing rocker shaft
E discharge-roll ram
F feed-roll ram
G rocker lever
H tension rod
J feed roll
K top roll
L discharge roll
M, N spacer blocks
O high-pressure housing
P low-pressure housing

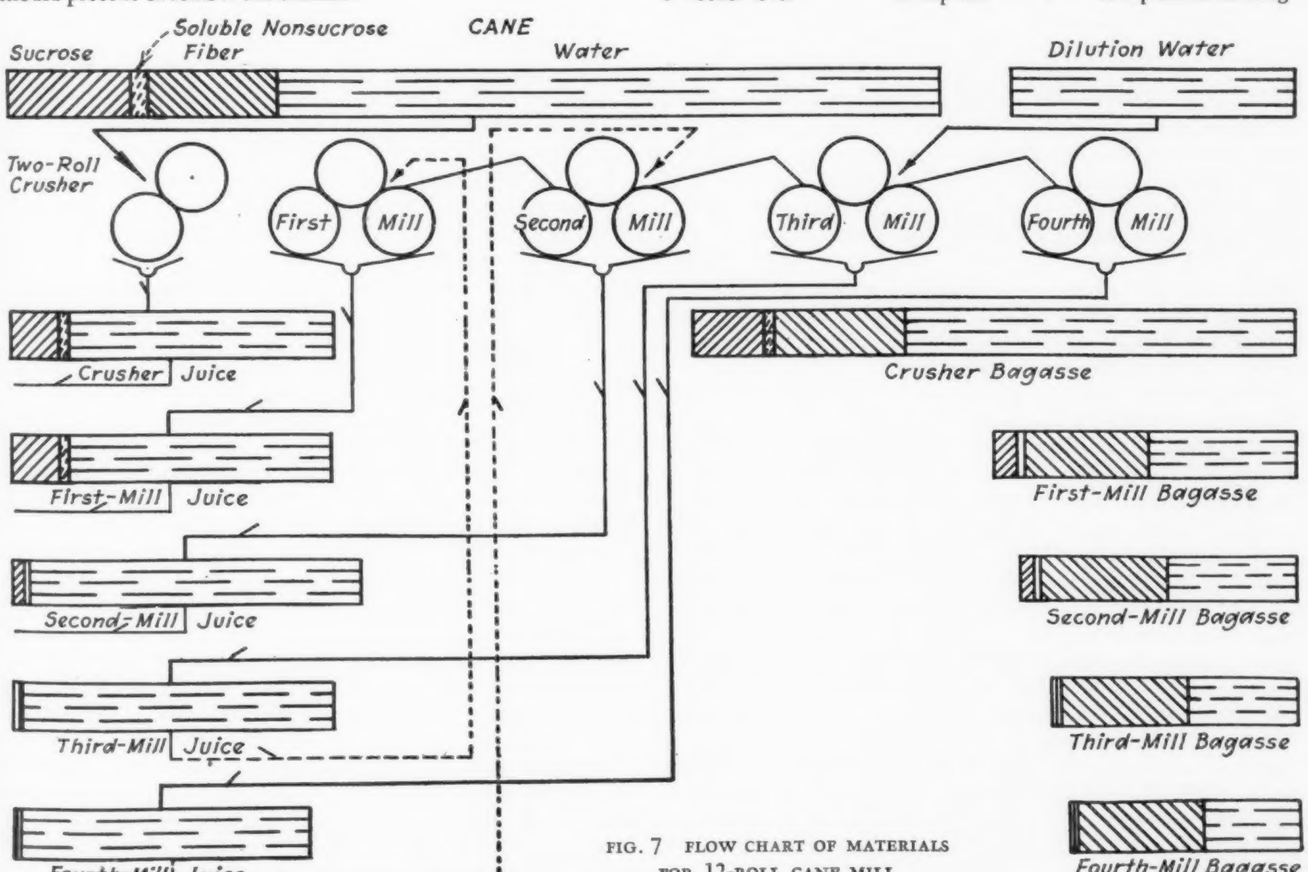

FIG. 7 FLOW CHART OF MATERIALS FOR 12-ROLL CANE MILL

	Per cent
Sucrose in cane	13.5
Fiber in cane	14.0
Normal juice purity[a]	87.0

	Per cent
Juice purity, last mill	65.0
Dilution, to weight of cane	30.0
Total sucrose extraction	97.5
Moisture in final bagasse	42.0

[a] Juice purity is the ratio of the sucrose in the juice to the total soluble solids in the juice as determined by use of a hydrometer calibrated with the Brix scale.

Crushers are listed as preparatory equipment but they also extract a large amount of juice from the cane. Their preparation consists in splitting the cane and tearing and cutting it into small pieces. They serve to increase capacity, provide more uniform feed to the mills, and in addition extract under good conditions from 60 to 65 per cent of the juice from the cane. Their high initial cost per unit increase in capacity is a distinct handicap when compared with revolving knives for example. Experience indicates that maximum capacity and extraction necessitate a uniform and heavy feed to the mills. Preparatory equipment serves this purpose. Crushers and knives together seem to be the most favored combination of equipment at this time.

It would be a great aid to efficiency if some satisfactory equation or rule could be evolved for use in setting cane mills. By setting is meant adjusting the feed and bagasse rolls with respect to the top roll so that the opening between rolls will be such as to permit satisfactory feeding of the mill combined with a maximum extraction of juice. The question of roll openings naturally will depend upon the amount of cane it is proposed to grind in unit time, its fiber content, and the peripheral speed of the mill rolls. Since all three of these variables change from time to time, and usually quite suddenly, there is some question as to the wisdom of making elaborate calculation to determine mill settings. Three years ago a questionnaire sent out to the leading manufacturers of cane mills in the world elicited the information that numerous empirical methods of calculating roll openings for a given set of conditions are used but that the results obtained are usually considered as only first approximations. Starting with the calculated openings the operator feels his way along as it were until he strikes a combination that gives best results. A serious drawback to this trial-and-success method is the length of time required to establish optimum settings for different grinding rates expressed as tons of fiber passed per hour. Even in the best of modern mills considerable time is required to change mill settings and a still longer time is needed for the metal scrapers which keep the rollers free of bagasse to wear in to their new position on the rolls. The expense attendant on such delays makes the operator hesitant to change settings as long as his mill is performing reasonably well.

A factor which has a pronounced effect on capacity and to a less extent on sucrose extraction is mill speed. For convenience peripheral speed of the rolls in feet per minute is used rather than rpm. Other things being equal it follows that the faster the rolls turn the more cane they should crush in a given period of time. Continuing along this same line of reasoning, a mill 3 ft wide and running at 50 fpm should grind as much cane as a 6-ft mill does at 25 fpm. If this be true, the possibility appears of reducing the capital investment in factories by using small high-speed mills rather than large slow ones. Mill speeds were formerly limited to from 20 to 25 fpm by the materials used in their construction. Molded gearing and mill housings were made of cast iron and higher speeds than 25 fpm were too risky. The use of cut-tooth steel gearing and cast-steel housing together with improved bearings and more efficient lubrication makes operation at speeds of from 40 to 60 fpm quite satisfactory. The problem now is, what is the economic and physical limit to mill speeds? This question will be considered further along in the paper.

As the last of the factors to be considered here, there is the question of maceration. Preparation and squeezing alone are not sufficient to remove satisfactorily the sugar from the cane. After two or three good pressings all the liquid has been removed from the cane residue or bagasse but the fiber still contains a large amount of sugar. This last sugar may be removed by soaking the bagasse in water and then pressing out the water along with the sugar which it has dissolved. Given sufficient time and enough water, complete extraction of sucrose is possible. The necessity of maintaining high grinding rates combined with inability to evaporate unlimited quantities of water sets certain practical limits. The amount of maceration water used is expressed in terms of per cent of the weight of cane ground. Where the evaporator capacity is sufficient, as much as 40 or 50 per cent maceration water may be applied. There is considerable question as to whether the extra sucrose recovered by heavy maceration justifies the cost involved. Mill operation at high speeds and capacities makes difficult the efficient utilization of maceration water. The bagasse mat coming from the mill is so thick that the water reaches only the surface layers. High mill speeds decrease the length of time the water is in contact with the bagasse and, since solution of sugar solids is relatively slow, this means higher sugar losses in the bagasse. To secure better extraction of sucrose and more efficient use of maceration, the total amount of water to be used is sprayed on the bagasse issuing from the penultimate mill in the tandem. This water and the material it has dissolved is squeezed out in the last mill of the train. This last-mill juice is quite low in dissolved solids so it is pumped on the bagasse emerging from the mill just before the penultimate. This process of compounding the maceration may be repeated several times until the first mill is reached whence the juice goes into process.

SATISFACTORY STUDY ONLY IN SPECIALLY DESIGNED PLANT

Numerous attempts have been made in commercial plants to study and evaluate the factors which have just been considered. Results indicate that the only satisfactory way to conduct such a study is to use a milling plant especially designed for experimental work. It was with this idea in mind that Audubon Sugar School of Louisiana State University purchased and installed in 1938 a modern experimental milling plant.

The milling unit was designed and built by the George L. Squier Manufacturing Company. It is made up of a set of revolving cane knives driven by a 40-hp 1200-rpm motor. There are eight blades in the set of knives. Following the knives is a 20 × 24-in. two-roll crusher, which is driven through totally enclosed gearing by a 50-hp d-c motor. Directly below the crusher is located a 24 × 24-in. Gruendler shredder, which is direct-connected to a 30-hp 1200-rpm motor. Three 18 × 24-in. three-roll cane mills complete the tandem. Each of these mills is independently driven through Falk gearing by 100-hp d-c motors. Air-type accumulators are employed to maintain a maximum operating pressure of 120 tons on the mill rolls and 75 tons on the crusher rolls.

The preparatory equipment is arranged so that any or all units can be thrown out of service and by-passed at will. A maximum of approximately three hours is required to cut out the cane knives, or restore them to service. A special arrangement of the crusher housing permits the raising of the crusher top-roll assembly a total distance of 12 in. It is locked into this new position, a special chute is slipped into the opening between the crusher rolls, and grinding can be resumed minus the action of the crusher. A maximum period of an hour is needed to make these changes. The shredder can be put into or out of service in ten minutes. This is the time required to open or close a gate in the chute between the crusher and first mill, and to engage or disengage the intermediate carrier between the shredder and the first mill. These features greatly facilitate the conduct of tests of various methods or preparation. The unit can be operated as a simple nine-roller mill or as a nine-roller mill with any or all of the various preparatory devices.

Extreme flexibility in mill speeds is provided by the Ward-Leonard system for electric mill drive. The General Electric Company designed and manufactured all of the electrical

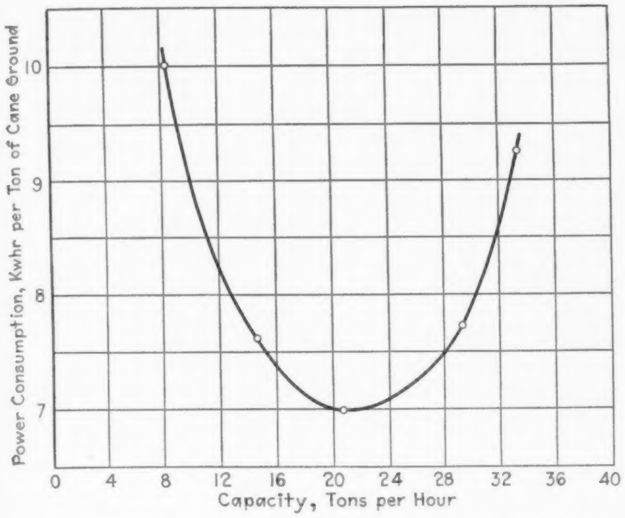

FIG. 8 CAPACITY VERSUS POWER CONSUMPTION FOR 18 × 24-IN. MILLS

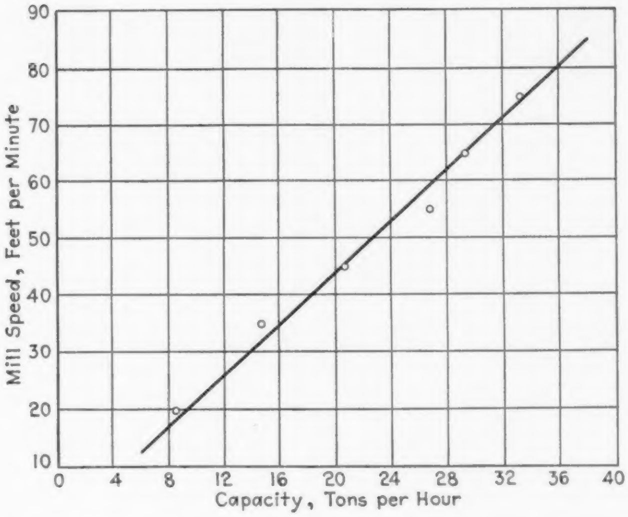

FIG. 9 CAPACITY VERSUS THE MILL SPEED FOR 18 × 24-IN. MILLS

equipment for the mill installation. This includes a 300-kw 250-v d-c generator driven by a 435-kva 2300-v 60-cycle synchronous motor, and a 50-kw motor generator set which provides independent excitation for the fields of the main generator and the mill motors. The motor generator set and its accompanying switch gear are set up in a control room adjacent to the mill room of the factory. All controls needed for normal operation are mounted on an operator's panel, which is located near the crusher. This panel carries push buttons for starting and stopping each mill motor and the crusher motor independently. The direct-current generator voltage and the speed of the mill motors can be altered at will through manipulation of a control rheostat mounted on the panel. Rheostats are also provided for each individual motor field, so that in addition to variation of the speed of the tandem as a whole, it is also possible to vary the speed of each mill and the crusher independently, within reasonable limits. The mill roll-surface speed can be varied from a minimum of 20 to a maximum of 80 fpm. Individual strip-type recording ammeters are provided for each of the mill and crusher motors. The total power consumption of all these motors is obtained by a master watthour meter. Power consumption of the shredder and knives, which are driven by a-c motors, is recorded on individual strip-type wattmeters. Starting switches for the motors which operate cane knives, shredder, cane carrier, juice strainer, and the various juice and maceration pumps are all mounted on the operator's platform, which commands an excellent view of the entire mill.

A mill for experimental work must be able to withstand considerably more abuse than a normally operated commercial unit. Experiments involving high roll speeds and high pressure put severe strains on gearing, housing, and rolls. The crusher and mills of this unit are all driven through double-reduction herringbone-gear units which were built by the Falk Corporation. These units are extremely efficient and exceptionally quiet-running. The mill housings are of the Squier triangular-stress type and are made of cast steel. The crown gears on the crusher and mills are of steel with cut teeth. Mill and crusher journals are all of the same diameter, 9 in., with a bearing surface 13 in. in length. Brasses are water-cooled. Forced-feed lubrication is employed.

PROGRAM OF INVESTIGATIONAL WORK

The program of investigational work laid out for the plant includes a study of relative values of the various types of preparatory equipment, i.e., knives, crusher, and shredder as judged by their effect on capacity and sucrose extraction; the effect of roll speed on capacity, power consumption, and sucrose extraction; the effect of temperature on the efficiency of maceration; determination of the optimum amount of maceration under Louisiana conditions; and a study of the power requirements of the various components of the unit, such as scrapers, intermediate carriers, gearing, and the like.

It is felt that sufficient information has not been accumulated at this time to justify any conclusive statements regarding the various topics investigated. Such data and statements as are here presented are necessarily preliminary only.

One of the prime requisites for satisfactory test work is stable uninterrupted operation. During the first season's operation of this milling plant which extended over a period of 40 days this condition was seldom realized. As with most cane-milling plants it was necessary to spend considerable time in adjusting the various units to obtain most satisfactory operation.

The mills were first set to grind at the rate of 15 tons of cane per hr at 35 fpm roll speed. The openings were reduced at intervals until at the end of the season they were set for 10 tons per hr at 30 fpm. Sufficient interval had to be allowed between setting changes for the iron scraper tips to wear to a new seating position on the roll surface. Settings were changed four times during the 40-day operating season. With an extremely flexible unit such as this, the problem of proper setting is much greater than in most units since from lowest speed to highest the capacity increases fivefold.

A series of tests was conducted to determine capacity, efficiency, and power consumption. Fig. 8 shows a curve of power consumption versus capacity and Fig. 9 gives the relationship between roll speed and capacity. The efficiency as judged by the percentage extracted of sucrose in the cane was approximately the same at all speeds. It remains to be seen whether subsequent work with the plant will confirm these results.

Problems to be investigated during the next season include repetition of the work of this season, and in addition a study of the effect on mill performance of the cane shredder, cane knives, and the two-roll crusher; determination of the economic limit of maceration; and the effect on extraction of varying the pressure on the mills.

It is unfortunate that so much time must elapse between seasons. It means that almost five years are required to do what could be accomplished in one year of continuous operation.

New Developments in

WELDING FITTINGS

By E. HALL TAYLOR

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NEW DEVELOPMENTS in welding fittings have come about so gradually that most users are not aware of the type changes and of the improvements in fittings that are now available.

Of first importance from the user's standpoint is the new "Proposed Standard for Welding Fittings."[1] This new standard covers the over-all dimensions of elbows, tees, caps, reducers, return bends, and lap-joint stub ends. It also covers the pressure rating, size, marking, material, metal thickness, tolerance, and the welding bevel.

Engineering departments can, now, with these standards established, lay out pipe lines with the knowledge that the fitting manufacturers are now making changes to conform to the new proposed dimensions.[1]

The angle of the bevel for butt welding has finally been agreed upon in this new standard. The bevel formerly used was 45 deg and the new bevel is $37^1/_2$ deg. This bevel has been in use in pipe-line work for some time. As fast as changes can be made, the $37^1/_2$-deg bevel will be adopted on welding fittings. The narrow groove formed by this bevel has the advantage of requiring less weld metal, thus saving time and material.

Welding small-diameter pipe has always presented a problem in lining up and in welding. The wall thickness of pipe in sizes of 2 in. and under is of course comparatively thin. When this is beveled for welding, the narrow bevel is not easy to line up with the pipe, and welding the thin wall requires care to avoid burning through. The development of socket welding fittings several years ago solved these difficulties but it has been only recently that they have come into widespread use. It is easy to center pipe in a socket fitting as the pipe slips into the end of the fitting for a short distance. A fillet weld is made between the fitting and the pipe. There is no danger of burning through as this weld is on the outside of the pipe. The strength of these fittings is such that, as many tests to destruction have showed, the pipe always fails before the fitting shows distress. Socket fittings are now produced by several manufacturers and their use should do much to increase the welding of pipe in sizes of 2 in. and smaller.

New developments in welding methods have steadily improved weld quality and increased the speed of welding. This has done much to further the installation of welded piping systems. It can safely be said that the quality of welding today is such that in every case the welded joint is equal to or stronger than the pipe itself. The same statement should hold true of welding fittings in order to give a full-strength pipe line throughout. In order to accomplish this, fittings have been reinforced at the points of greatest strain. Tests to destruction have been conducted on many fittings in which the seamless pipe has burst before the fittings, showing how well this reinforcing has strengthened the fitting against deformation.

The reinforcing of branch connections

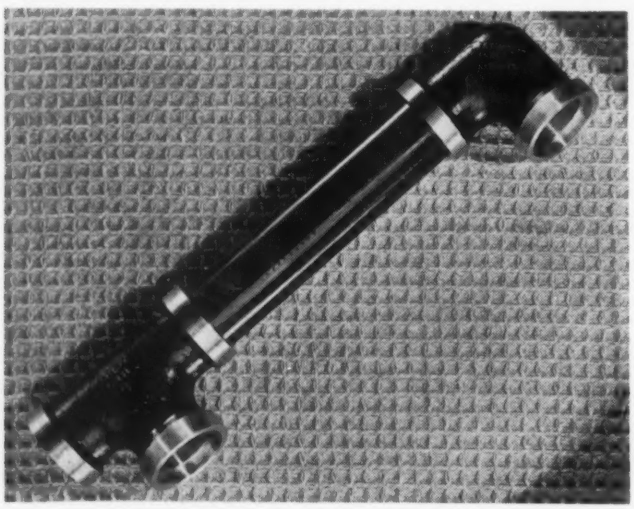

FIG. 1 SOCKET-TEE AND -ELBOW ASSEMBLY

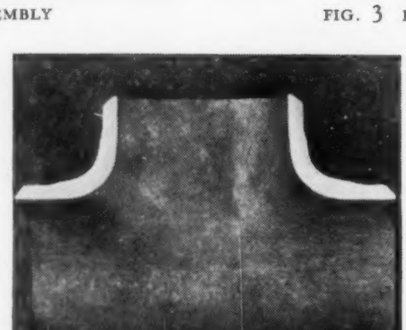

FIG. 2 SEAMLESS REINFORCED TEE

FIG. 3 BURSTING TEST, 8-IN. TEE ASSEMBLY

[1] Now in the course of preparation by The American Society of Mechanical Engineers under A.S.A. procedure.

Presented at the 39th Annual Convention of the International Acetylene Association, Houston, Texas, March 8-10, 1939.

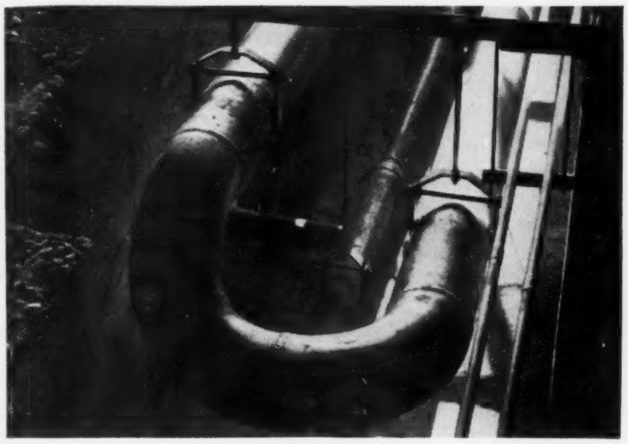

FIG. 4 OFFSET EXPANSION LOOP

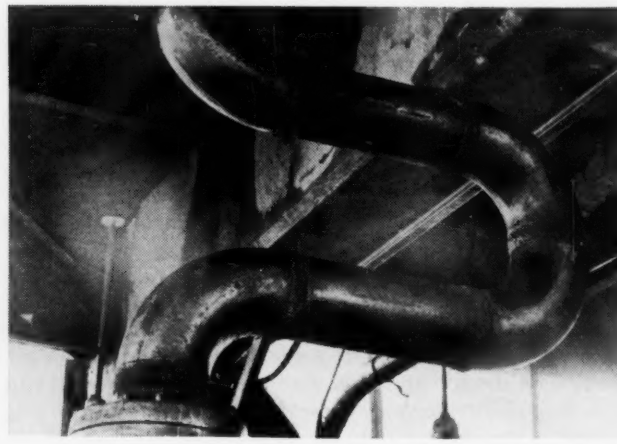

FIG. 5 EXPANSION LOOP

FIG. 6 NESTED EXPANSION LOOPS

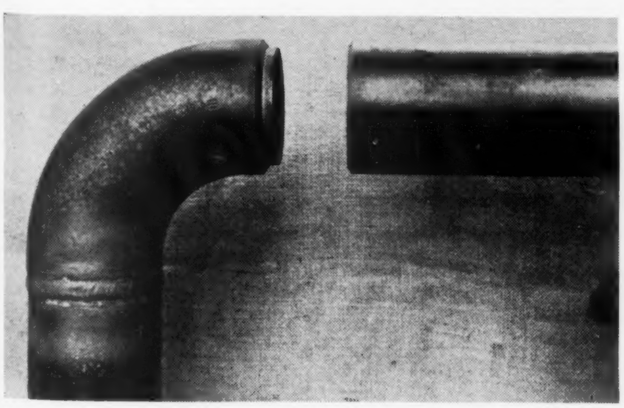

FIG. 7 ASSEMBLING CENTERING-RING FITTING

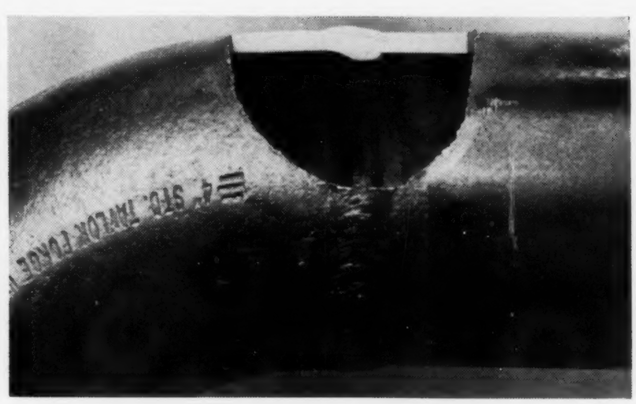

FIG. 8 CLOSE-UP OF CENTERING-RING JOINT

attached to pipe by welding has assumed such importance that a committee has been formed by the American Standards Association to study this subject and make recommendations for addenda to the Code for Pressure Piping. Extensive tests are being run by the members of this committee to determine just what the strains are and what reinforcement is necessary when a hole is cut in a pipe for a branch connection. It is not generally recognized how much a pipe is weakened when a hole is cut in it for a branch outlet. Welding tees are designed with reinforcement around the branch so that the strength of the tee is approximately equal to the yield point of the pipe, thus eliminating any weakness at the outlet connection.

Another use for welding fittings, and one that is growing all the time, is for the forming of expansion loops. Expansion

loops made of welding fittings are flexible and can easily be made to fit almost every expansion condition and requirement. The simple requirements for making a loop are cutting the pipe to length and assembling it with welding fittings. The amount of the expansion regulates the length of the loop, the elbow serves as a flexible pivot point, and the expansion is absorbed by the flexing of the pipe. This is a simple, inexpensive, and safe way to take care of expansion in a pipe line.

In the last two years, the design of the hub on butt-weld flanges has been so improved that there is no danger of the heat of welding warping the face of the flange. Warping has been encountered in some cases where slip-on flanges were used as the weld is so near the face of the flange that the heat has some effect upon it. In some cases it has been necessary to machine the face of the slip-on flange after welding. The use of butt-weld flanges eliminates any danger of warping and the need for remachining.

It is well known that welding is used today on practically every installation that requires high quality. However, there are many low-pressure installations where the user feels welding is too costly. It has been the object in making new developments in welding fittings to produce a fitting that will lower the cost of a welded installation. Now the cost of welding a fitting into the line is not just the cost of making the weld; that is often the smallest part of the cost of making a joint. Often the largest part of this cost is that of making ready, laying out, cutting and fitting, and lining up to get ready to weld. These are the costs that have been reduced by new developments in fittings.

In welding operations on piping, the first step is to insure the welding operator's getting the right fitting for the job. This may seem a small item, but shop men know how much time can be wasted looking up tickets and tags and checking dimension tables, trying to identify fittings from a stock pile full of various sizes and standards. Positive identification has been provided by stamping into the fitting its size and standard. Anyone without any knowledge of pipe standards can easily indentify a fitting so stamped.

Given the right fitting, the next problem is that of lining it up. Fittings are accurately beveled by machine so there is no problem in their joining evenly against the pipe end. The real time lost is in trying to determine the angle at which the fitting should be turned so as to fit the next run of piping. An angle cannot be measured without some reference point to start from, so the center line of the fitting must first be determined. This takes time and is not the easiest thing to do on an irregularly shaped object like an elbow. Hence has come the new development of marking center lines on elbows. These center lines are machine-marked for accuracy and with them as reference points it is easy to determine any angle at which it is wished to place the elbow.

Lining up the welding fitting so that it is concentric with the pipe end is a problem on which many have worked. Various jigs and clamps have been made to do this; some of them are helpful and time can often be saved by using them, but such aids to lining up are not always available. A new fitting which lines itself up has now been developed which has a centering ring as part of the fitting. This centering ring, forged integral with the fitting, centers the elbow into the pipe, thus assuring accurate alignment instantly without any leveling or shimming. The ring will support the pipe end and hold it in readiness for welding, thus eliminating the need for extra supports. In addition to saving time in lining up, this ring has been found to improve the strength of the joint weld by assuring complete penetration. The centering lip acts as a backing ring for the weld metal so that the joint can be welded all the way down to the bottom of the bevel without danger of burning through. This condition is much harder to obtain with the bevel only. The ring stops weld metal from flowing inside the pipe, thus preventing the formation of projections or icicles to obstruct the flow. The ring is an integral part of the elbow so that there is no danger of its coming loose in the line. It is so small and fits so snugly to the pipe that there is no measurable friction loss.

The developments in welding and welding fittings have only begun and it is believed that progress will be so rapid and such quality and economy will be demonstrated that soon all pipe lines, large and small, will be welded.

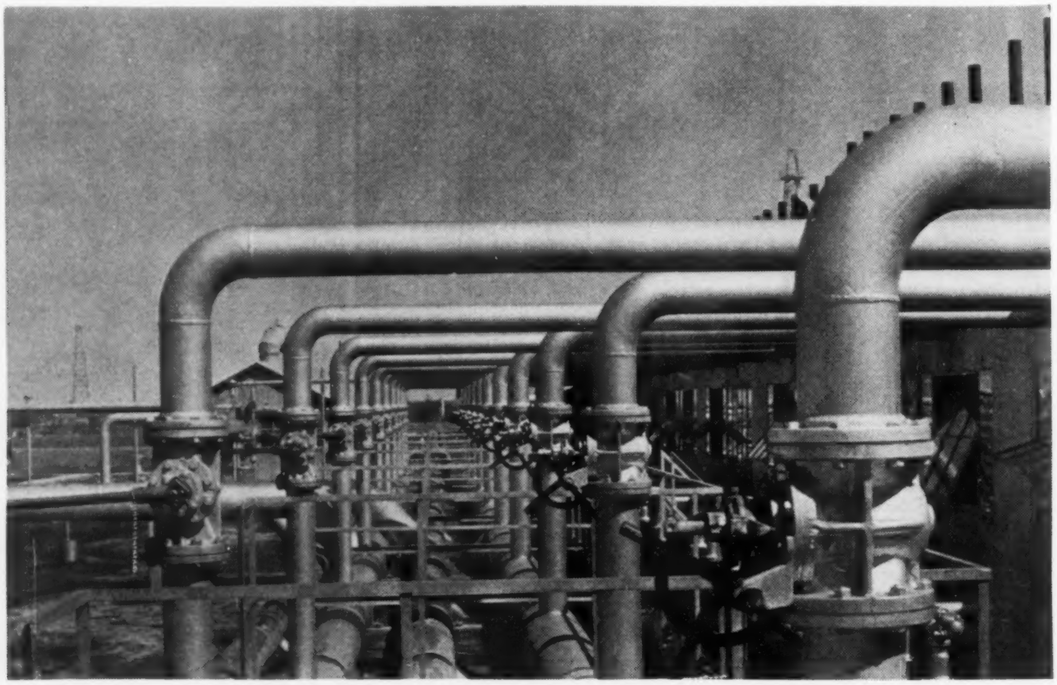

FIG. 9 WELDED PIPING INSTALLATION

SCIENTIFIC MANAGEMENT *in the* SMALL BUSINESS

By J. ANSEL BROOKS

NEWARK COLLEGE OF ENGINEERING, NEWARK, N. J.

A BUSINESS does not have to be big to be efficient or progressive, yet many small businesses are not taking full advantage of the economies of modern management. This article deals primarily with the application of scientific-management principles to small business, the business that employs a few workers or a few hundred workers. It includes comments on some management tools and mechanisms, but it does not explain the technique of management operation.

Scientific management, often spoken of as modern management, is defined as "the scientific selection, control, and disposition of methods, money, men, manufacturing, marketing, and measurement."[1] This definition includes a broad field of management activities, yet an industrial plant, having a good cost-accounting system, or a wage-incentive system, or a motion-and-time-study department, is often referred to as a plant with scientific management. That is, the mechanisms of scientific management are often confused with the principles.

The four basic principles of scientific management are: (*a*) Continual research for the purpose of determining policies and procedures; (*b*) the establishment of standards of policies and procedures, based on the results of research; (*c*) control of all operations in terms of the established standards; (*d*) co-operation or the stabilization of human relationships.

RESEARCH AS A FUNCTION OF MANAGEMENT

Research in finance, production, and sales is an important function of management. It makes possible the substitution of facts for guesses and rule-of-thumb methods. Many small businesses, however, cannot finance an extensive research program. This fact should not prevent the small business from applying this principle of scientific management at least to a few of management's mechanisms, later extending the program, when and as finances permit. If this method is adopted as a standard policy and if the first mechanisms to be investigated and studied are those which show promise of the greatest financial returns, then later, research may pay its own way.

Any business, particularly the small business, should take advantage of the results of prior research by others. Many of these results may be obtained from the periodical, *Factory Management and Maintenance*, the publications of The Society for the Advancement of Management, The American Society of Mechanical Engineers, The American Management Association, The American Standards Association, The United States Department of Commerce, and others.

Research should be a continuing function of management in any business and should be established as a standard policy. In the small business, the methods used in research and the standards resulting from research may differ from those in the large business. Nevertheless, the purpose is the same, namely, the elimination of unnecessary wastes.

This article does not include all the management problems to which this principle of scientific management might be applied. It does, however, comment on some of the management mechanisms which the small business now using rule-of-thumb methods might investigate for the purpose of establishing scientifically determined standards.

MAINTENANCE OF EQUIPMENT

Maintenance is a function of management and, if a plant is looked upon as a machine, maintenance can be considered as a tool or a mechanism which can be used to make the plant more efficient. Maintenance is an indirect expense and for this reason, or others, its cost is often kept too low. Hence, unit cost of production is not decreased but increased. This increase is due to one or more of the following: Too rapid depreciation of equipment; inferior quality of products caused by faulty equipment; decreased output caused by inefficient equipment; interruptions in plant operation resulting from breakdowns; costly repairs. Therefore, the purpose of maintenance is, in so far as practicable, to prevent too rapid depreciation of equipment, to prevent equipment from becoming inefficient or faulty in action, to prevent breakdowns, to prevent repairs.

Before a maintenance program is set up, the general policy might be established that maintenance will be preplanned, scheduled, and controlled in terms of established standards.

Preplanning involves a study of past records and experiences, standard practice, and perhaps tests for the purpose of determining what is to be done, how it is to be done, when it is to be done (time intervals), and by whom. From this study standards will be determined and control methods devised.

What is to be done will include such items as cleaning, painting, oiling, calibrating, adjusting, replacing, dismantling (in anticipation of trouble), and minor repairs. How it is to be done and when it is to be done should be recorded and should become standard procedures. By whom it is to be done will depend upon the plant organization. However, the best results should be obtained when authority and responsibility are centralized.

The purpose of maintenance, which is prevention, can be attained only by periodic inspection. Therefore, inspection should be scheduled and standard methods of inspection should be used.

The maintenance program should fit the requirements of the business. The maintenance work may be done by a department or as the part-time duty of one man. Nevertheless, maintenance in the small business can be and should be preplanned and controlled.

CLASSIFICATION AND SYMBOLS

Classification is the grouping together of items that have similar characteristics; symbols are the abbreviations of items of the classification. Every business has some method of classification and most businesses use symbols. Yet groupings, terminology, and symbols are often confusing and cause delays and mistakes. Classifying material things and activities is

[1] "Modern Management," by J. E. Walters, John Wiley & Sons, Inc., New York, N. Y., 1937.

Presented at a meeting in New York, N. Y., Feb. 8, 1939, of the Management Division, Metropolitan Section, of The American Society of Mechanical Engineers.

helpful in visualizing and understanding them. It is essential for proper comparison, filing, recording, and identification. Good classification tends to prevent mistakes in purchasing, storing, fabricating, cost finding, general accounting, etc. Symbols are the characters representing the items of classification. Mnemonic symbols assist the memory and are, therefore, preferable to others. Classification is essential to the orderly arrangement of facts.

PLANT LAYOUT A MATTER OF RESEARCH

Many small plants can be found in which very little or no study has been given to plant layout. The layout in these plants has often been based on opinions and not on the results of investigation. A scientific investigation of these layouts would reveal many things contrary to good management. It is, therefore, a subject to which small business could profitably apply the research principle of scientific management.

Plant layout is the arrangement of departments and equipment. A good layout is one which secures a smooth and rapid flow of work. Therefore, most problems which concern a change in the flow of work are problems in plant layout. In the small plant there are, as in the large plant, several types of layout problems: (*a*) A general change (plant or departmental) in the method of manufacturing, that is, from the departmental method to the continuous, or from continuous to the departmental; (*b*) a rearrangement throughout the plant or a department; (*c*) a change at one workplace. If the problem is one of making a change at one workplace, a study should be made of the effect this change may have at other workplaces. That is, changing the flow of work at one workplace may, to obtain the best results, necessitate changes at others.

Before making any change in layout it is advisable to make a process chart and a flow chart. These charts should form the basis for the study. From them some of the following changes in the flow of work may be suggested: The elimination of backtracking, storage between operations and bottlenecks; elimination of some handling, or a change in handling methods; elimination and combination of operations, or a change in operation methods or sequence; relocation of machines and workplaces. A template layout of the plant or of a department should be made when a relocation of equipment is contemplated. Also, before making some of these suggested changes, time-and-motion studies should be made.

A poor plant layout results in inefficiency. Small business has the opportunity, by means of scientific investigation, to secure a better flow of work, thereby increasing plant capacity and decreasing unit costs.

MOTION-AND-TIME STUDY

Of the numerous management mechanisms, motion study and time study have probably received the greatest amount of attention, favorable and unfavorable. Much of the unfavorable criticism of time study and of motion-and-time study is due to a misunderstanding of the real purpose of these studies and to fear of the misuse of results obtained from them. Much of this misunderstanding can be overcome by education.

A motion-and-time study, as the words indicate, includes a study of motions and times, yet time studies are made without a study of the motions, and motion studies are made which are not followed by accurate time studies. In certain instances these studies have value. However, for the best results motions and times should be included in the study.

Motion-and-time study is a scientific method of analyzing (*a*) the motions employed in performing an operation, (*b*) the equipment used, (*c*) the surrounding conditions which might affect the results of the study, (*d*) the time required to perform the operation.

The ultimate aim of this analysis is job standardization, that is, the setting up of standard specifications for the performance of an operation or job. A standard specification should embody those items which, at the time, are the best under the conditions. Thus, items which result in waste of time, energy, and material are altered or eliminated.

Job standardization, through the medium of motion-and-time study together with a system for controlling the work in terms of the standards, should result in determining the best manner of performing the work (including better working conditions), a fairer measure of work for rate setting, fewer delays (dependent upon the production-control system), increased wages, and decreased unit costs.

Motion-and-time study is another mechanism of management which can be used advantageously in a business of any size. It offers the small business an opportunity to eliminate much waste which has crept in due to the lack of a scientific analysis of operations.

RAW-MATERIAL STOREROOM

Three basic principles of scientific management are the principle of research, the principle of standards, and the principle of control. A good illustration of the nonapplication of these principles can be found in the storerooms of many small plants.

In these storerooms the absence of research can be noted by an examination of storeroom layout, stores classification and marking, raw-material specifications, simplification of raw materials, safekeeping and correct issuing of materials, and inventory method. Standards may exist but, if there has been no research, they are probably based on habit or guesswork. Control may exist for some of the functions of storekeeping, but seldom for all of them.

Much waste can be eliminated if these three principles of scientific management are applied to the operation of the storeroom. The benefits that can be obtained by means of a well-organized and controlled storeroom are a more orderly storeroom, less floor space, material easily found and moved, less obsolete material, less misuse and diversion of material to improper use, more uniform quality of material, greater certainty of adequate supply of material, and less money tied up in inventories.

The mechanisms for controlling inventories are simple and effective. One of them, the balance-of-stores ledger, can do much to eliminate wastes and should be used in every business.

Due to the great loss that can and does occur through improperly organized and controlled storerooms, much of which can be eliminated easily, it is surprising that there is not a more general application of scientific management to storerooms.

SMALL BUSINESS SHOULD ADOPT STANDARDS

The importance of standards has already been mentioned. One of the principles of scientific management is that of standards, yet in many plants, large and small, variations exist in methods, times, procedures, and policies. A successful system of management requires standards. The purpose of research should be to establish standards. Small business should start or continue to establish standards based on research.

These management mechanisms and others, such as simplification, standard costs, budgetary control, etc., can be used by small business. In some instances it may be possible and practicable to install one or two of them at the start and perhaps others later; for example, a good system of classification and a maintenance program based on research, standards, and control. It is not necessary that small business use the same techniques, policies, forms, etc., which might be used in large business, but it can apply the principles of good management, namely, research, standards, control, and cooperation.

The MECHANICS *of* HUMAN ORGANIZATION

By CONRAD M. ARENSBERG

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IN THIS volume[1] Mr. Barnard, president of the New Jersey Bell Telephone Company, makes an imposing contribution toward a synthesis of the many studies of human relations in industry that are beginning to develop a new appraisal of the life and organization of the large-scale institutions of the present. Mr. Barnard brings an extensive theoretical reading of sociology and psychology and a wide practical experience of affairs to the problem. He tells us that he has often found executives and others in large-scale organizations able to understand one another with very few words in discussion of organization problems only to lose common understanding immediately whenever either technical illustrations or theoretical questions were brought up. Appeal to the results of scholarship in the social sciences yields many explanations of the forces at work in the relations of those on the job but it yields no agreement upon which such discussions might draw. Consequently, Mr. Barnard has culled his own experience of industrial enterprise and combined it with testimony drawn from other large-scale institutions of quite different purposes, such as the army and the church. These groups of men banded together for one purpose or another, with their diverse techniques and complex interrelations and their recurrent administrative problems, have one thing at least in common. They are "cooperative systems." The task, then, is to describe the uniformities such cooperative systems present as functioning organizations, in the actual present experience of their members and leaders, apart from their historical development.

Such a task is necessarily immense, and a book reporting on it is necessarily extraordinarily difficult, both to write and to read. The difficulty is not in the style; Mr. Barnard has written succinctly and well. It is in the matter itself.

In the first place, the attitude of detached observation and the divorce from historical perspective which Mr. Barnard adopts and holds until the last chapter will be strange and even repulsive to many people. For him and for many others working in the attempt to bring scientific method to the discovery and understanding of human behavior, the important thing is not an ethical prescription for action or a moral or even an economic evaluation of large-scale human organizations. It is rather an objective inquiry into the nature and structure of such phenomena, the conditions of their existence, and the forces in human nature of which they make use. To argue that human nature is incalculable, that human action is immensurable, that human will is recalcitrant, and human action foolish and arbitrary, so that men cannot be reduced to scientific objects like chemical compounds or molecules, is to prejudge such effort. Mr. Barnard's purpose is to make just such a reduction, if only on a preliminary, approximate basis. The test of his success must be sought in its correspondence with the experience of others in similar cases.

In the second place, Mr. Barnard's purpose necessarily cuts across provinces claimed by each of the social sciences. He must necessarily take some kind of stand upon matters still controversial in each of them, in order to attain a unified picture. Thus he is forced to make some assessment of claims and theories as to the biological, psychological, sociological, and economic nature of men and the incentives and rewards that call forth their action as members of large-scale organizations. It is interesting that in doing this Mr. Barnard takes his stand with those who repudiate many of the current economic dogmas and discount the all-importance of monetary incentives. As inducements to cooperative action, he finds that emotional satisfactions and nonlogical sentiments have far greater power than material rewards. He says specifically: "Notwithstanding the great emphasis upon material incentives in modern times and especially in current affairs, there is no doubt in my mind that, unaided by other motives, material rewards constitute weak incentives beyond the level of the bare psychological necessities."

Consequently, Mr. Barnard stresses strongly the importance, to executives of whatever kind of organization, of conscious or unconscious recognition that the formal organization of blueprint, chart, and constitution, with its neat and "logical" provision of status, responsibilities, obligations, and rewards, is not the whole story of cooperation. There is present always and everywhere an informal organization as well, upon which the vitality of the effort depends. To disregard or neglect it is a fatal error. In this, Mr. Barnard emphasizes the growing realization among both social scientists and practical men that some sort of "politics" is a necessary component of human affairs of every kind. Politics indeed has an efficiency of its own, not perhaps recognizable to the zealot, the stickler for form, the technical expert, but indispensable in the ordering of human relations in organized effort. The concept of authority to which observation leads Mr. Barnard takes this fact into account. Authority rests quite literally in the consent of the governed, however it is won. The process of executive decision must take informal organization and human emotion and habit into account.

The chief difficulty that prevents such realization and precludes the development of knowledge about it is the lack of a framework of ideas and words in which to put it. Unless a uniform manner of communicating information about it can be created, the problem of the "human element" in organized enterprise, from the selection of personnel to the conduct of industrial and public relations, will remain what it is, a matter of art and intuition and painful experience. Mr. Barnard estimates that there are not less than five million persons engaged in executive work in some capacity or another in this country. Of these perhaps some hundred thousands make decisions of major social and economic importance in the lives of large numbers of their countrymen. There is no lack of literature and instruction upon the technical aspects of the fields in which they work. But, as Mr. Barnard points out, "concerning the instrumentality with which they work—organization—and the techniques appropriate to it, there is little. And more im-

[1] "The Functions of the Executive," by Chester I. Barnard. Harvard University Press, Cambridge, Mass., 1938.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

portant still is the lack of an accepted conceptual scheme with which to exchange their thought."

Such a scheme for the exchange of thought implies a good deal more than the search for a "formula." The engineer or executive who would reduce human relations to a formula as simple as that of the expansion of gases is guilty of immense naiveté. So is the man, trained in the liberal arts or the social sciences, who asserts belligerently that human action is too complex and too fluid ever to be charted according to law. Both of them mistake the purpose and the accomplishment of scientific method. Science has scored its triumphs as a precise and consistent shorthand for objective description of recurrent events. The field of human interaction, which gives rise to the social sciences which embrace the theory and practice of the arts of organization, has its share of recurrent events. Yet a shorthand to record them is still lacking and must be found.

Mr. Barnard has sensed the existence of such a necessary next step in the understanding of human relations. He pleads for a redefinition of conventional specialization in the nonphysicochemical sciences in order to allow a view of the events of human situations as a whole. His experience and the evidence he marshals in this book demonstrate that failure of organized enterprise springs very often from inability to look at and act upon enough of the elements of cooperative situations. Failure arises in concrete instances where an insufficient number of the elements of human interaction have been taken into account. In practical affairs, a grasp of the elements as a whole may well be entirely intuitive. The resulting decision, if successful, is then an example of "good judgment." But then, he points out, it succeeds not because of but in spite of the thinking in which it is clothed. Far too frequently, however, the thinking that prevails leads directly to "bad judgment" and the destruction of cooperation, not because it is wrong, but because it is inadequate.

"Important consequences of this state of affairs," says Mr. Barnard, "are unbalance and false emphasis upon matters concerning which there is already much knowledge and appropriate language—for example, in the technologies like accounting and financial practice, in certain aspects of personnel work—and a concomitant disregard of equally important matters which heretofore have not been much discussed." Some of the significant omissions he cites are these: Disregard of the subjective aspect of authority, disregard of the existence and importance of informal organization, false emphasis upon intellectual and mental processes, false emphasis upon logic and self-interest, neglect of social compatibility, neglect of customary practices and attitudes, neglect of feelings of prestige.

The book is thus to be considered not only as a preliminary description of large-scale organization—a world that has been very little reported at all—but also as a plea for a new attitude toward such things. It is thus a work in sociology addressed to executives, engineers, personnel men, and management on the one hand, and the public of the social sciences on the other. It will probably surprise many of the first category that their experience of mill and office is a fit subject for scientific inquiry at all. It will surprise them more that the president of a huge modern industrial concern should exhort them to think so. Yet just this kind of development has preceded the growth of other sciences in their formative periods.

For the book is also a plea for collaboration in objective research between the practical man, engineer, executive, personnel man, whose work involves human cooperation with tools and things, and the theorist of social action. The practical man is condemned to rule-of-thumb procedures if he has no objective and general theory for his problems. The theorist is condemned to arid speculation if he is not continually prodded with real problems and everyday factual experience. Such collaboration is as necessary in forming a knowledge of how human beings behave as it ever was in building up knowledge of what chemicals do under various conditions. If theorist and practitioner of human relations on the job and in organizations are to get together and evolve a common means of communication, build up a mass of observation, and create inventions for social life, they must continue the willingness Mr. Barnard shows. They must learn to make use of one another's skills.

The FEDERAL GOVERNMENT *and* RESEARCH

By A. A. POTTER

PURDUE UNIVERSITY

INDUSTRIES which have made the most spectacular growth during the last 25 years are also foremost in research. American industrial laboratories employ 25,000 research workers and spend $100,000,000 a year for research in order to develop new methods, new machinery, and improved materials. Some industries appropriate 2 to 4 per cent of their gross income for research. Research is an integral part of any organization which is interested in efficiency, in long-range goals, and in linking the present with the future. Bankers are recognizing that the research program of an industry is a safe guide to the investment value of its securities.

From the earliest days of our national history the United States government has conducted investigation, of a greater or lesser scientific character, in order to establish a sound basis for its legislative and administrative activities. Congress is not only a creator of research agencies, but is itself engaged, through its committees, in investigations mainly in the social-science field. The federal government has assumed responsibility for research with special reference to agriculture, national defense, the conservation of natural resources, and the development and maintenance of physical standards.

Research by the federal government comprises investigations in both the natural and social sciences, and their applications, including the collection, compilation, and analysis of statistical, mapping, and other data which may result in new knowledge.

The National Resources Committee, with the approval of the President of the United States of America, has made a survey of the relation of the federal government to research, and published its findings in December, 1938, in a report entitled, "Research—A National Resource." This paper is mainly a review of this report.

During 1936–1937 the United States government expended

120 million dollars for research, or about one dollar per capita of its population. Seventy million dollars were derived from general funds and 50 million from emergency funds. For 1937 the research expenditure was 124 million dollars, of which 54 million were derived from emergency funds. Government research expenditures in the social-science field have increased materially and involve about one quarter of the regular funds and nearly all of the emergency research funds. One half of one per cent of the federal budget is the average amount spent for research.

AGRICULTURAL INVESTIGATIONS PREDOMINATE

Investigations in agriculture predominate among the fields of governmental research with more than one third of all the regular research funds devoted to agriculture, an increase of two and one-half times in 15 years. Next to agriculture comes research for improved military and naval equipment and techniques, which account for about one fifth of the regular research expenditure. Aeronautical research represents one eighth.

About 125 federal bureaus and independent agencies are engaged in some form of research, and about the same number carry on no research. The list of government research projects is large but includes mainly the fields of agriculture, defense, weather interpretation, public health, physical and biological problems inherent in the public domain or federal possessions, mental health, crime control, life and culture of the American people, physical and biological research involved in international relations, population changes, economic indexes, labor problems, standards of living, governmental finance, and determination of standards.

The federal government is obligated to carry on research in fields in which there is a constitutional responsibility, such as national defense and the determination of standards; fields in which the government performs essential regulatory functions, such as control of traffic in foods and drugs and supervision of power production; fields in which extensive administrative or construction functions have become a federal responsibility, as in the case of flood control and highway construction; fields in which the major problems are of a definitely national or interstate character, like agriculture, weather forecasting, and fisheries; and fields of research which lead to new products for which there is no market, except in wartime, and no incentive for private industry, except to the extent that it is federally subsidized.

The federal government is also better equipped to carry on research which is very costly, such as aeronautic research, investigations and surveys in geology, geodesy, mineral technology, public health, and soil conservation.

The authority, prestige, and resources of the federal government may be used to organize and direct research in any given field on a national scale. Agricultural research, for example, is coordinated through state experiment stations. The War and Navy departments keep continually informed as to developments in industry. The National Advisory Committee for Aeronautics through its laboratory serves as a central research plant for both industry and government alike.

The work of state agricultural experiment stations is an example of effective decentralized research which is stimulated by and carried on in close cooperation with government. The Public Health Service maintains relations with medical schools and with state boards of health.

During the Civil War the National Academy of Sciences was chartered to make available to the government the talents of the scientific men of the country. During the World War the National Research Council was organized to supplement the National Academy of Sciences in bringing to the government the services of the nation's research workers in the fields of natural science, anthropology, and psychology. The Division of Cultural Relations of the Department of State is intended to bring about intellectual cooperation between this and other countries.

Progress demands new standards, new kinds of measurement, and ever-increasing accuracy. The Bureau of Standards performs these functions for the benefit of industry, the government, and the public at large.

The numerous activities of the U. S. Department of Agriculture have grown up invariably in response to demands from farmers for assistance in solving practical problems which could not be handled by individual effort. Agriculture is a major industry which is nation-wide in scope. The Department of Agriculture is the largest single research organization in the world and is the center of agricultural research. Through field laboratories, grants-in-aid, extension activities, and cooperative relations with federal, state, and private agencies the department in a measure directs all research work in agriculture. There are 7500 research workers in the department and in state agricultural experiment stations who are active in improving agriculture. Each state receives a grant of $90,000 for agricultural research in addition to its proportionate share under the Bankhead-Jones Act of 1935, which will reach three million dollars by 1940. States more than match federal grants for agricultural research.

The basic act for agricultural research is the statute creating the Department of Agriculture in 1862 and setting it up as a research agency. The creation in 1884 of the Bureau of Animal Industry extends this function. Then follows the Hatch Act, 1887, extending federal support to states for agricultural research. The Adams Act of 1906 allows additional agricultural-research funds. The most recent legislation is the Bankhead-Jones Act of 1935, which is an amendment to the Land-Grant College Act "to conduct research into laws and principles underlying basic problems of agriculture in its broadest aspects."

The Forest Research Act, or the McSweeney-McNary Act, of 1928, is intended to encourage forestry research.

A closely knit, highly centralized form of organization is typified by the Navy Department. All of its activities are pointed toward the single end of national defense. National defense requires constant research to develop new weapons and improved materials of war.

N.A.C.A. MAINLY A RESEARCH AGENCY

The National Advisory Committee for Aeronautics was created by Congress in 1915 and is mainly a research agency. It has the largest and best-equipped aeronautical-research laboratory in the world at Langley Field, Va. Leading foreign countries have sent aeronautical missions to this country to study N.A.C.A. research organization and laboratories.

The U. S. Geological Survey is the largest contributor to geological science and the results of its findings are of value to the mining and petroleum industries, as well as to those concerned with the construction of highways, bridges, water storage, and similar works. River flow and investigations of wells are within the field of the Geological Survey.

The Bureau of Mines is national in scope in its relation to mining and metallurgy. It grew out of the Geological Survey and is intended to carry on scientific and technological investigations in mining.

The Coast and Geodetic Survey maps coast lines, investigates tides and currents, and makes geodetic control surveys on which surveying and mapping operations depend.

Public health knows no state lines, and drugs are articles of interstate commerce.

Governmental research has acted in many cases as a stimulus

to industry; examples of this are nitrate fertilizer research by the Bureau of Chemistry and Soils, boiler scaling and embrittlement of boiler steels by the Bureau of Mines, and the new industries which have grown out of the work of the Bureau of Fisheries on oil and fish-liver oils. The Navy Department has been an important factor in developing the steel industry through its insistence on steel plates for battleships as early as 1883. Steel castings were first made in this country in 1887 to meet Navy requirements.

The Social Security Board is expected to carry on investigations in the fields of old-age pensions, unemployment, accident compensation, and the like.

Regulatory commissions, which have as their primary functions regulation rather than research, sponsor research as an important activity. Thus, the Interstate Commerce Commission has authority to "inquire into the management of the business of all common carriers." The Federal Trade Commission is empowered to "investigate the organization, business conduct, practices, and management of any corporation engaged in commerce. Its activities encompass foreign countries as well as the United States.

The National Bituminous Coal Commission is expected "to conduct research designed to improve methods used in the mining, preparation, conservation, distribution, and utilization of coal, and the discovery of new uses for coal."

The fields of research open to the Federal Power Commission, Bituminous Coal Commission, U. S. Maritime Commission, Federal Communications Commission, and other agencies are as fully specified as are those of the Bureau of Reclamation, Rural Electrification Administrator, Vocational Educational Board, and the Civilian Vocational Rehabilitation Board.

The Tennessee Valley Authority is authorized to undertake "experiments for the purpose of enabling that corporation to furnish nitrogen products for military purpose and for agricultural purposes." Other research agencies are the Federal Housing Administration, Federal Reserve Board, Bureau of Census, Bureau of Foreign and Domestic Commerce, and the Tariff Commission.

The Bureau of Census furnishes social-science data and carries on social-science research of great value to the public. The Congressional Library aids the collection and interpretation of research information.

About 10,000 persons are employed in research positions with the government. In 1896 only about 2.3 per cent of the civilian positions in executive civil service involved professional, scientific, and technical functions as contrasted with 12.7 per cent in January, 1937. From 1931 to 1937 social-science research workers under civil-service classification have increased 17.28 per cent as compared with 9.31 per cent in the physical sciences.

The recruiting, placement, and in-service training of research workers in the government are not as satisfactory as in industry or higher educational institutions. Most of the investigators in the government bureaus are selected from civil-service lists and at salaries of \$2000 to \$9000 per year. The present civil-service procedure places the government at a disadvantage in recruiting and in holding the highest type of scientific and technological personnel in competition with industry, universities, or other scientific agencies. The government, in most bureaus, fails to train its promising young research workers in newly developed techniques.

The bureaus and agencies of government have the privilege of going outside the civil service for the employment of experts in a consulting capacity or to investigate special problems. The usual compensation of such experts varies from \$10 per day in the Bureau of Mines to \$50 per day in the Bureau of Reclamation. Advisory committees, such as the Visitors of the Naval Observatory or the Visiting Committee of the Bureau of Standards, serve without pay.

Any consideration of the relation of the federal government to research is incomplete without some mention of what is done by colleges and universities, particularly those supported by public funds. All research agencies, including the government, must rely upon higher educational institutions for research personnel and for leadership in pure research. In 1876 only 25 universities conferred the Ph.D. degree and 44 such degrees were conferred that year; 2709 Ph.D. degrees were conferred by 86 institutions of higher learning in 1937. One quarter to one third of those who receive the Ph.D. degree continue in research.

A large part of the research in universities is independent and unorganized, controlled directly or chiefly by the interests of the individual professor. Of the 1450 American colleges and universities, 150 expended for all purposes during the year 1935–1936 about 265 million dollars, and of this about 50 millions were spent for research. The remaining 1300 spent a total of 155 million dollars and about one million for research.

About one quarter of the income of 20 leading universities is claimed to be spent for research. Those spending more than 2 million per year are: California, Chicago, Columbia, Harvard, Illinois, and Michigan; $1^1/_2$ to 2 million dollars, Cornell, Minnesota, Wisconsin, and Yale; 1 to $1^1/_2$ million dollars, Massachusetts Institute of Technology, New York University, Ohio State University, and University of Pennsylvania; $^1/_2$ to 1 million dollars, Purdue, Iowa State College, Iowa University, Penn State, Texas A.andM. In many of the institutions the agricultural experiment station funds aid in making the totals appear conspicuous. In most of the land-grant colleges and universities little research, outside of agricultural research, is carried on.

An unbiased analysis of the research activities of our government leads one to conclude that the scientific contributions of the 125 bureaus and independent agencies are of high order and of distinct benefit to agriculture, national defense, and the public at large. There is need for more scientific research by government to control national defense, to create new opportunities for employment, to improve the products of the farm and shop, and to raise living standards.

Metal Cutting

(Continued from page 355)

this way the hardness and toughness of tungsten carbide is combined with the low heat conductivity and low coefficient of friction which characterizes tantalum carbide. In order to provide further resistance to oxidation as well as the attainment of a highly polished machined finish, titanium carbide is occasionally added to tungsten carbide and to mixtures of tungsten and tantalum carbides.

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WORCESTER REED WARNER MEDAL

A.S.M.E. HONORS AND AWARDS

VII—Worcester Reed Warner Medal

WORCESTER REED WARNER, charter member of The American Society of Mechanical Engineers, manager from 1890 to 1893, president in 1897, and honorary member from 1925, was cofounder with Ambrose Swasey in 1880 of The Warner & Swasey Company, known the world over as builders of accurate-production machine tools, some of the largest astronomical telescopes and mountings, and other instruments of precision. Up to the time of his death in 1929 at the age of 83, Mr. Warner was a familiar and welcome figure at A.S.M.E. headquarters, business and professional meetings, banquets, and excursions. He personally knew hundreds of members, both old and young, and inspired all to develop to the full the possibilities of an engineering career.

During his 49 years of membership in the A.S.M.E., Mr. Warner gave liberally of his time and talents in promoting the welfare of the Society, and at his death, the following bequest was found in his will:

"I give and bequeath to The American Society of Mechanical Engineers $25,000 in perpetual trust to be invested and the income to be used to establish and provide an annual award of a gold medal to be bestowed on the author of the paper adjudged worthiest to receive such recognition; said paper to deal with progressive ideas in mechanical engineering or efficiency in management; and the medal to be known as the 'Worcester Reed Warner Medal.' "

Upon the recommendation of the Board of Honors and Awards of the Society, the Council at its meeting in October, 1929, passed the following resolution:

"That in accepting the bequest of $25,000 made by the late Worcester Reed Warner, past-president and honorary member of The American Society of Mechanical Engineers, for the foundation of the Worcester Reed Warner Medal, the Council of the Society expresses the high regard in which it holds the memory of this Charter Member and fellow worker for the best interests of our Society. As a manufacturer, as a man of affairs, and as a creator, his life will be an incentive to our members for more earnest endeavors. This bequest for the recognition of outstanding papers dealing with 'progressive ideas in mechanical engineering or efficiency in management' indicates the field of labor to which he devoted the many years of a successful life."

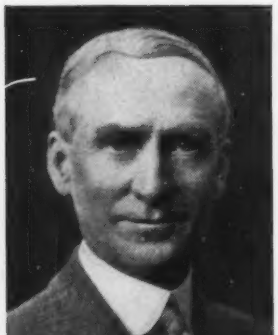
At the same time, the Board was authorized to proceed with the design of the medal by a suitable artist and the cutting of the dies. Julio Kilenyi, the sculptor of the Society's Fiftieth Anniversary Medal, was selected to execute the Warner Medal. Valued assistance was rendered to the Board and to the sculptor by Mrs. Warner and Ambrose Swasey, who directed the work and approved the final designs.

BASIS OF AWARD

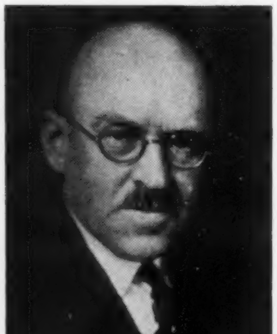
The Board of Honors and Awards in carrying out the terms of the Warner deed of gift has recommended to the Council as recipients for the Worcester Reed Warner Medal, engineers who have made noteworthy contributions to the permanent literature of engineering. Under the direction of the Board the Worcester Reed Warner Medal is awarded annually for a book or books, or a single paper or group of papers, which has been recognized as constituting an outstanding contribution to engineering literature. To apply this test a considerable period of time must elapse between the presentation or publication of the work on which the award is based, and the review of it which must be made by the Board's Committee on Medals to determine its value to the engineering profession. The distinction between the Warner and Melville medals is at once apparent. The latter is awarded for a current paper to the Society; the former is an honor bestowed for a contribution of long standing which has lived and attained a place of its own in engineering literature.

Although the first award of the Worcester Reed Warner

The seventh of a series of articles prepared under the direction of the Board of Honors and Awards of The American Society of Mechanical Engineers, better to acquaint the members of the Society concerning the honors and awards which are given in recognition of meritorious achievements of engineers.



D. S. KIMBALL



R. E. FLANDERS

S. P. TIMOSHENKO

C. M. ALLEN

C. F. HIRSHFELD

L. H. FRY

Recipients of the Warner Medal

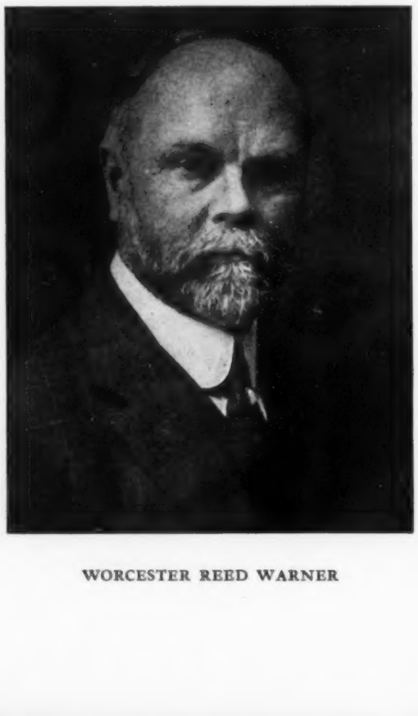
Medal was made as recently as 1933, the list of medalists already contains names of distinguished engineers, and the work for which these men have been honored relates to a number of branches of mechanical engineering.

MEDALISTS

DEXTER SIMPSON KIMBALL, Fellow A.S.M.E., past-president of the Society, and dean emeritus of engineering, Cornell University, was the first recipient of the Worcester Reed Warner Medal (1933) for his contributions to efficiency in management as exemplified by his book, "Principles of Industrial Organization," widely used as a text in engineering schools, and by his many articles, which number almost 300, in the Transactions of the A.S.M.E., MECHANICAL ENGINEERING, and other engineering and technical publications.

RALPH E. FLANDERS, Fellow A.S.M.E., past-president of the Society, and president of Jones & Lamson Machine Company, was awarded the 1934 Worcester Reed Warner Medal for his contributions to a better understanding of the relationship of the engineer to economic problems and social trends as exemplified by the many papers he has presented, including his paper before the A.S.M.E. in 1924, "The Design, Manufacture, and Production Control of a Standard Machine," which brought a successful solution to the problem of building machinery economically at widely varying rates of demand.

STEPHEN P. TIMOSHENKO, Fellow A.S.M.E., professor of theoretical and applied mechanics, Stanford University, received the 1935 Worcester Reed Warner Medal for his contributions to the theory of the design of elastic structures and the treatment of dynamics of moving machinery. Dr. Timoshenko was active in the organization of the Applied Mechanics Division of the Society. He has contributed many papers to Society meetings and publications and is author of several books relating to the subjects for which he was honored by the award.



WORCESTER REED WARNER

CHARLES METCALF ALLEN, Fellow A.S.M.E., past vice-president of the Society, and professor of hydraulic engineering at Worcester Polytechnic Institute, was selected as the recipient of the 1936 Worcester Reed Warner Medal for his early and continued hydraulic-laboratory work and for the permanent value of his papers on the development of methods of testing large hydraulic-turbine installations. Several of his papers have been presented before the Society and published in Transactions of the A.S.M.E. and MECHANICAL ENGINEERING.

CLARENCE FLOYD HIRSHFELD, Fellow A.S.M.E., past vice-president of the Society, and chief of research, The Detroit Edison Company, received the 1937 Worcester Reed Warner Medal for his research and contributions to the theory and practice of heat-power engineering as exemplified by books and papers. Another achievement of Dr. Hirshfeld was his application of modern research methods to the production of an entirely new type of electric streetcar which is economical to build and operate, combines light weight with increased strength, and eliminates many of the defects of former streetcars through improved riding comfort, agility, and quietness.

LAWFORD H. FRY, Member A.S.M.E., and railway engineer, Edgewater Steel Company, was awarded the 1938 Worcester Reed Warner Medal for his contributions relating to improved locomotive-boiler design and utilization of better materials in railway equipment. Mr. Fry has been a contributor of papers to the Transactions of the A.S.M.E. and an adviser on technical committees. He is the author of the well-known text, "A Study of the Locomotive Boiler," and has contributed authoritative articles to the A.S.M.E. Transactions, MECHANICAL ENGINEERING, and other engineering periodicals.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

EVENTS abroad take place with such astounding swiftness and irrationality that comment on them as they affect engineers becomes more and more speculative. Reaction in this country to these events is so widespread that no one can remain unconscious of them, even if their meaning and consequences remain obscure. Until the shadow of uncetainty cast by the European situation is lifted, a resumption of the hoped-for upswing in business in the United States is likely to be hesitant.

Dependence of this country upon others for certain essential raw materials the supply of which would be interrupted by a general war and surplus in the country of other commodities equally essential to some European countries have prompted a bargain agreement, announced on April 11, between the United States, Great Britain, Holland, and Belgium calling for an exchange of American wheat and cotton for rubber and tin from the other three countries.

Events at home continue to reflect the clash of opposing social, economic, and political philosophies. Little is heard of the program to encourage and reassure business that was talked about when Mr. Hopkins assumed his cabinet post as Secretary of Commerce. Revisions and reforms in tax, labor relations, and wages and hours laws do not get beyond the discussion stage. Although the spending philosophy is meeting opposition, it is still in the saddle. In this connection an analysis by the National Industrial Conference Board of the results of five years of pump priming shows that "for every borrowed dollar spent by the federal government, at most only 64 cents was received by the people of the United States in the form of yearly real income of goods and services. . . Actually, in the five years, 1934–1938 inclusive, the government increased the national debt by $14 billion. Instead of the vast increase in national income which fiscal theorists expected, however, the gain in yearly real income (eliminating the effect of price changes) was only $9 billion. "Even if all this increase can be credited to pump priming," says the report, "each bucketful of primer has produced less than two thirds of a bucket from the well."

In the meantime, according to the same authority, there was an increase in unemployment amounting to 103,000 from January to February. The February unemployment figure was 10,760,000, which included 3,373,000 workers in the government labor force. The nation enjoys prosperity when a maximum number of persons are at work producing goods and services. Mechanical engineers perform vital functions in the enterprises involved in these activities, many of which are essential to the acceleration of the wealth-producing process, such as improved techniques and the development of new goods and services. But the stimulus for acceleration comes from capital invested in the hope of profit. Regardless of what the factors are that discourage investment, an end to unemployment under our system of free enterprise would seem to wait upon correcting conditions that cause the discouragement.

Capital Goods

The dependence of many mechanical engineers on the healthy functioning of the capital-goods industries lends interest to a publication of the Machinery and Allied Products Institute, of Chicago, that appeared early in April under the title, "Capital Goods and the American Enterprise System." Accustomed for generations to take the American system of free enterprise for granted, to develop it, to correct, as occasion demanded, its defects, and to adapt it to a changing social and political environment, industrialists have been slow to comprehend the reasons, born of world-wide as well as domestic misfortunes, for popular distrust of it and active efforts to change it. The public too has taken the system for granted without understanding what it is or what makes it work. Facile proponents of other systems and persons acting from a variety of motives have put the American system on the spot. Individually and sporadically groups of industrialists have attempted to defend the system under which they operate and to explain it to the public. Explanation is the object sought by the 90-page book referred to, which bears the subtitle "a statement of economic and social principles underlying the numerous interrelationships of the capital-goods industries and the American enterprise system," and in which acknowledgment is made to George H. Houston, member A.S.M.E. "for his contribution to this work."

In the introduction are briefly outlined two fundamentally different concepts of society, the individualist concept (capitalism) and the collective concept, the conflicts that arise between these concepts and the issue of national economic planning, the role played by individualism in the past, and economic questions arising out of current national trends that must be faced in the immediate future. In a series of five chapters are discussed, with relation to the American enterprise system, its technological aspects, the significance of capital goods, savings and investment, obstructions to the flow of capital into employment-making enterprise, and essentials to economic recovery. The tone of the book is temperate and objective, and it has the virtue of compressing, with commendable clarity of expression, much information into a few pages.

National Defense

Reflecting conditions that are disturbing the peace of the world, discussions of the problems of national defense have been growing more numerous and have demanded an increasing amount of public attention. A frequent and leading figure in these discussions has been Louis Johnson, the Assistant Secretary of War, who, because he is concerned with the problem of procurement, finds industrialists and engineers attentive

THE OLD ABBEYDALE WORKS WHICH THE SOCIETY FOR THE PRESERVATION OF OLD SHEFFIELD TOOLS PROPOSES TO REPAIR SO THAT IT MAY SERVE AS AN INDUSTRIAL MUSEUM. THESE WORKS ARE DRIVEN BY FOUR WATER WHEELS. THE WIDE CHIMNEY IS FROM THE 5-HOLE CRUCIBLE MELTING FURNACES

listeners. On April 5, the evening before Army Day, Secretary Johnson and Rear-Admiral Clark H. Woodward, U. S. N., addressed the National Industrial Preparedness Dinner of several engineering and technical groups organized as the American Conference on National Defense, at the Waldorf-Astoria, in New York. More than a thousand prominent industrialists and men of affairs participated in the dinner, including about one hundred members of the A.S.M.E.

Secretary Johnson told how the industries were responding to government appeals to build up in this country stocks of important raw materials for which the nation was obliged to depend upon foreign sources of supply, how the rubber industry was intensifying its efforts to produce a substitute, and how the electrical-power industry was cooperating by the installation of about a million kilowatts of additional capacity.

Admiral Woodward praised the President's larger-navy policies, and emphasized the importance of industry to the Navy in its building program and in equipment supply in event of war, and especially mentioned the cooperation necessary to step up aircraft manufacture to a mass-production basis in case emergency defense measures demanded it.

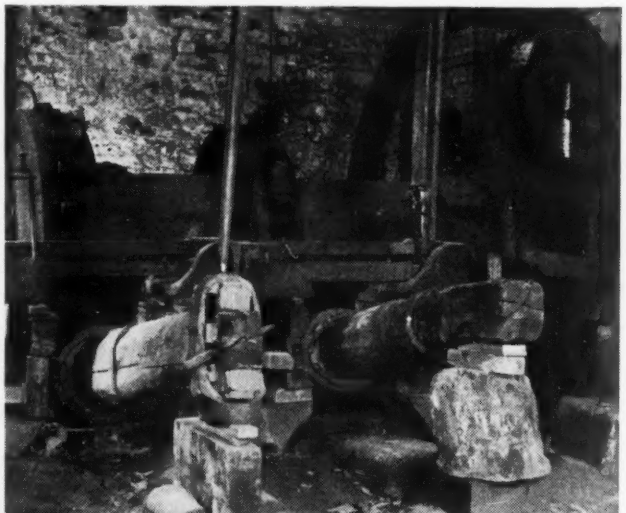
Col. Frederick H. Payne, who acted as toastmaster, said that "the factories of America are part of our frontiers, wherever they may be, and that our engineers and manufacturers are shoulder to shoulder with the officers and men of the fighting forces." He added that the occasion gave all present an opportunity "to rededicate ourselves to the national defense of the United States, for no other purpose, public or private, individual or collective, than to maintain the peace and security of our country."

The American Society of Mechanical Engineers was represented in the Conference and at the dinner by President A. G. Christie, W. C. Dickerman, and the secretary, C. E. Davies.

Sheffield Museum

W. H. Bolton, secretary, Society for the Preservation of Old Sheffield Tools, has sent us a number of copies of a circular on the proposed Sheffield Industrial Museum. The circular contains an appeal for funds to save from demolition the Abbeydale Works, Beauchief, Sheffield, England, a former cutlery-manufacturing plant. The Abbeydale Works with its dam and surrounding land were purchased and presented to the City of Sheffield by the J. G. Graves' Trust. It is proposed to preserve the unique water wheels, tilt hammers, and scythe-making equipment, and to supplement these by other hand-forging tools and anvils. These are to constitute a permanent exhibition of machinery and tools formerly used by Sheffield craftsmen, famous internationally for their skill in producing fine cutlery.

If a fund of £1500 can be raised for necessary repairs, the city will take over the museum when completed. Mr. Bolton writes that £400 has already been promised. He has sent several photographs showing exterior and interior views of the Works, of which two are reproduced on this page. Space does not permit full description of the 200-year-old Works, which contain one of the first rolling mills ever made, or of the machinery and tools that will form the historical collection. In view of the background of British craftsmanship which many engineers and industrial concerns in this country have, it is thought that some of them would be interested in helping to preserve the Abbeydale Works. Mr. Bolton's ad-



TWO OF THE OLD TILT OR TAIL HAMMERS IN THE ABBEYDALE WORKS. THE REVOLVING WOODEN SHAFT AT THE REAR IS PROVIDED WITH CAMS OR NOTCHES WHICH DEPRESS THE FAR END OF THE WOODEN HAMMER SHAFTS. UNDER SUCH HAMMERS SHEFFIELD CRAFTSMEN FORGED SCYTHES IN THE OLD WORKS

BAS-RELIEF OF GARDNER CHACE ANTHONY UNVEILED IN ROBINSON HALL, TUFTS COLLEGE, MARCH 26, 1939

dress is Department of Applied Science, St. George's Square, Sheffield, England.

Gardner Chace Anthony

In memory of Gardner Chace Anthony, dean of the Engineering School, Tufts College, from 1898 until his retirement and for more than 50 years a member of the A.S.M.E., a bronze bas-relief shown in the illustration on this page, was unveiled in Robinson Hall, on March 26.

Dean Anthony was a familiar figure in engineering and educational circles where he was greatly admired and beloved. In accepting the tablet in the name of the college, Dr. Leonard Carmichael, president of the college, said in part: "Dean Anthony's wisdom and courage in no small way accounts for the distinction of this school today. His wisdom, his educational ideals, started it in the direction in which it is still going, and so those who are parts today of this administration must realize that what we are in a sense depends upon what Dean Anthony brought to this school and did in this school during the long years that he was so importantly directing its functions."

James D. Ross

Comment on the careers of engineers who attain national prominence is frequently offered in these columns. Because the nation recently lost, in the death of James D. Ross, of Seattle, a prominent and useful public servant, who had been highly honored by the President, an appropriate note was called for, and hence W. H. Onken, Jr., former editor of the *Electrical World*, was appealed to. Mr. Onken has graciously provided the following brief sketch of a man he had known for many years.

James D. Ross, superintendent of the municipal lighting system of Seattle, Wash., and administrator of the federal hydroelectric project on the Columbia River at Bonneville, Ore., died at the Mayo Clinic, Rochester, Minn. on March 14 at the age of sixty-six. Born in Chatham, Ontario, Nov. 9, 1872, the son of a horticulturist, Mr. Ross migrated to the Pacific Northwest and settled in Seattle at the beginning of the century. There he worked as an electrician, and when in 1902 a timber dam was erected at Cedar Falls for a domestic water-supply system for Seattle with electricity as a by-product, Mr. Ross was placed in charge of the initial development. His work at that time was rather primitive and shone only because of the prevailing darkness; but Ross was imaginative and practical and did not lack the lubrication of youth. Hence he was irrepressible, and "City Light" became the largest municipal system in the country and the forerunner of the two other famous muncipal lighting systems on the Pacific Coast which are also adjuncts to water-supply systems. Naturally, in so fast growing a community as Seattle in 1905, the demand for electricity soon exceeded the capacity of the hydrostation at Cedar Falls and it was not long before a 30,000-kw steam station was erected in the city of Seattle. This was followed soon after by Ross's monument, the hydro project on the Skagit River with its horticultural embellishments. Unlike most municipal systems, that at Seattle is financed from revenue bonds which are not liens against the general tax fund of the city. The utility is self-sustaining and the interest and principal are payable from earnings. Having thus established a nation-wide reputation as a successful manager of a municipal electric enterprise operating in competition with a larger utility corporation, Mr. Ross's services were in demand. F. D. Roosevelt when governor of New York consulted him regarding the New York Power Authority and the St. Lawrence River development; and he was so impressed with Mr. Ross's ability that when he became President he appointed him an advisory engineer in the Public Works Administration, next a member of the Securities and Exchange Commission, and finally administrator of the Bonneville project. Mr. Ross's ashes repose in an urn deposited in a granite rock overlooking the valley of the Skagit, the scene of his greatest engineering achievement.

New Optical Glass

SCIENCE NEWS LETTER

THE DISCOVERY of a way to make optical glass out of rare chemical elements instead of common silica permits the production of a glass which has a very high index of refraction and a low dispersion, it is disclosed in a patent just granted to Dr. George W. Morey, of the geophysical laboratory of the Carnegie Institution of Washington, D. C. According to a description of the new glass in *Science News Letter*, for March 25, 1939, the discovery may be a major stride in the advance of photography, permitting lens makers to produce "faster" and better lenses.

Some of the optical glasses of Dr. Morey have the highest index of refraction (light-bending power) ever reported; more than 2. Only comparable refraction is that of the diamond, which is about 2.41. Moreover, high index of refraction and low dispersion permit better corrections for chromatic aberration, the annoying property of some lenses of bringing different colors to different focuses.

Chemical elements most people have never heard of are used in producing the glass. Yttrium, lanthanum, columbium, hafnium, tantalum, zirconium, strontium, boron, and barium are some of the rare elements. The new work is a continuation of efforts made in the United States since the World War to produce better optical glass.

Alsifilm—A New Material

INDUSTRIAL BULLETIN OF ARTHUR D. LITTLE, INC.

A NEW TYPE of transparent film material, for which the name "Alsifilm" has been suggested, has been reported by Dr. Ernst A. Hauser, according to the *Industrial Bulletin* of Arthur D. Little, Inc. Alsifilm, it is said, can be made from clay and may find uses as a mica substitute, an indestructible paper, a fireproof wrapping material, and a waterproof coating for paper articles.

The clay used is an especially "pure" type of bentonite, made up of alumina, silica, and water, and the individual particles are so small that most of them fall within the colloidal range. It has been found that the finer part of the colloidal fraction of the clay when mixed with the appropriate amounts of water forms a gel. If this gel is evaporated, the particles draw toward one another in such positions that they become permanently fixed by their attraction for each other, in strings or tiny fibrils. These strings in turn mat together similarly to the matting of wood fibers in forming paper, or wool in felt, so that ultimately the resulting structure is that of a tough, coherent, independent film.

Alsifilm may be made thick so that it is stiff and brittle, and in this state is proposed as a substitute for mica, for it looks like mica, has similar electrical properties, and is chemically inert. Both mica and Alsifilm are composed of alumina, silica, and bound water, possibly in much the same proportions and distribution.

In presenting his findings to the Technical Association of the Pulp and Paper Industry, Dr. Hauser stated that the new film may be made completely inert to oils, greases, organic solvents, and strong acids and salts. There are obvious useful applications for such a material available as a film or a thread, and possessing these properties. In the thin, flexible form, for cable wrapping, it would offer long life and the needed electrical properties. Foods, especially those which tend to take up odors and tastes readily, might be packaged in this inorganic transparent film. Dr. Hauser also indicated that Alsifilm will take ordinary printing, colored inks, and printing pastes, or it may be colored throughout, filled and coated, oiled, or given a surface pattern. Unaffected by climate, mold, or insects, it is seen as a permanent record material, handled as easily as any paper.

Alsifilm is to be introduced commercially by the Research Corporation for the Massachusetts Institute of Technology and Dr. Hauser. At the present stage of development none of the material is available for distribution, but a small commercial unit is being constructed and samples will be available within a few months. The cost of Alsifilm cannot well be estimated until further progress toward the production of larger quantities has been made.

Mineral Wool

MINING AND METALLURGY

MINERAL WOOL is a substance composed of fine, interlaced mineral fibers having the appearance of loose wool or cotton. It is a fibrous, glasslike material composed principally of silicates of calcium and aluminum, with other minor constituents. The production of it has grown to such an extent that last year the output was valued at $30,000,000, as compared to an output in 1933 valued at $1,700,000. The industry is still growing vigorously and should profit from the expected activity in building in 1939, for two thirds of the material is used for building insulation and to assist in fire retarding, in both new and old houses. It is also a concomitant of air conditioning. A description of the production, fabrication, and application of mineral wool is contained in an article written by J. R. Thoenen, supervising engineer, U. S. Bureau of Mines, and published in the February, 1939, issue of *Mining and Metallurgy*, the journal of the A.I.M.E.

Mineral wool is a generic term, says Mr. Thoenen, covering a number of similar products differentiated chiefly by the raw materials from which they are made, such as rock wool, slag wool, and glass wool or glass silk. Rock wool, as its name implies, utilizes as raw materials limestone, dolomite, shale, and clay, combined with silica in the form of sandstone, or quartz, or as an ingredient of the other rocks. Slag wool is made from slags resulting from the reduction of iron, lead, or copper ores. Other materials, such as limestone or silica, may have to be added depending on the chemical analysis of the original slag. Glass wool is made from the same materials that are required for making glass. Basically, these are soda ash, limestone, and silica. The addition or partial substitution of other ingredients changes the characteristics of the glass; similar substitutions in the raw mix enable the manufacturer to alter the character of the wool blown.

In the manufacture of mineral wool, a stream of molten rock, slag, or glass is directed to a jet of either steam or air which blows it into wool. Technically, however, the process is not so simple, since many factors enter into the process, all of which must be under rigid control to assure a commercial product. Merely projecting a molten stream of rock into a jet of steam does not always produce wool. Chemical constituents of the raw material, degree of viscosity, and temperature of the slag, size of slag stream, length of fall, and the pressure of the steam or air are only a few of the many variables that must not only be controlled individually but coordinated to make the process successful in producing the kind of wool desired.

The usual process consists of mixing raw materials with coke in alternate layers in a water-jacketed steel cupola, igniting the coke, melting the rock-slag ingredients to a fluid molten slag,

tapping the slag through a small aperture, allowing the slag stream to drop to a steam jet, and blowing the slag in tiny droplets through the air, whereby friction elongates the droplet to a fine thread before it has time to solidify. These fine silicate threads form the wool and are then collected and fabricated into many forms of insulating products.

One manufacturer of rock wool has introduced a spinning disk, in place of the steam jet, which is revolved at high speed on a vertical axis. The molten stream issuing from the furnace falls to the outer section of the disk, whence it is violently propelled through the air in a manner similar to the action of the steam jet.

If conditions are not exactly right, part of the original globule will be cooled and solidified before it is drawn into fiber. Examination of most raw wools will show fibers still fastened to what is left of the original particle of molten slag. These solidified globules are known in the industry as "shot," a waste product.

In most plants the wool is blown into wool rooms as it leaves the steam jet. These rooms vary greatly in size and construction. Modern practice, however, requires a moving conveyer-type floor. Some wool rooms have elaborate ventilating systems, whereas others have no such provision. The wool collects on the moving floor and is carried out of the room in a blanket of quite uniform thickness, the latter being regulated by the rate of blowing and the speed of the conveyer. As the blanket emerges, it usually passes under a heavy idler roll which further compacts it to uniform thickness. In some plants the blanket, as it emerges, is sprayed with a liquid binder to increase its structural strength or to promote ease in handling the various shapes into which it may be cut.

Blankets intended for immediate fabrication are cut both longitudinally and transversely by knives or revolving disks into the sizes required for batts to be used in wall insulation between studding. These may be covered on one or both sides with plain or moistureproofed paper. They are then packed in cartons for shipment. Wool intended for other types of products is usually gathered from the conveyer and sent to the granulator, after which the shot is removed. These fine, shot-free fibers are bagged for shipment as granulated wool for blowing into the walls of houses already constructed.

Granulated or loose wool is also mixed with suitable binders and pressed or molded into insulating board, pipe covering, or other shapes. Mixed with clay or bentonite and asbestos, loose or granulated wool is sold as insulation cement. Mixed with water to form a paste, it can be formed around irregularly shaped objects as an insulating cover. Loose wool as taken from the conveyer is frequently placed between chicken wire or steel lath and sold in blanket form as insulation for steam-generating units in furnace walls and on ducts and bridgings, and in petroleum refining for insulating process vessels and heat exchangers. Railway cars and annealing ovens offer other outlets. Insulating board or blocks are made up to any specification size and thickness for stove or refrigeration insulation.

Insulation of houses against excessive heat or the escape of internal heat during the winter provides the greatest market for mineral wool. It has been found that mineral wool, $3^5/_8$ in. in thickness, has the same insulating value as 14 in. of yellow-pine lumber, 33 in. of plaster, 56 in. of brickwork, and 117 in. of concrete. However, the best insulator of all is empty space, as illustrated by the vacuum bottle. The next best, practically, is still air. In modern frame construction, the walls of houses contain a dead-air space between the outside sheathing and inside plaster separated into vertical panels by the studding. In masonry or brick construction similar dead air is found in the furring spaces. Even if all these dead-air spaces were hermetically sealed, movement of air within each panel would occur, thus reducing its insulating value. But when filled with mineral wool, the original space is converted into millions of tiny air pockets entrapped by the interlaced wool fibers. The fibers thus prevent air currents or, in fact, any air movement. Mineral wool thus converts the dead-air spaces of house construction to still-air spaces.

Danger Units

THE TRAVELERS INSURANCE COMPANY

A NEW and unique concept of driving danger in terms of "danger units" is introduced in a booklet entitled, "Lest We Regret," just issued by The Travelers Insurance Company. It is pointed out that energy increases progressively as the speed of a car increases, but that the increment in energy far outstrips the addition in miles per hour.

Using the term "danger units" instead of "energy units" or "hidden forces" seems practical. In danger units or D. U.'s simple numbers tell the facts about the death-dealing energy which rides with a person who goes too fast. The energy to be absorbed if a person strikes an object while running 25 mph is just the same as if he fell a height of 20.9 ft. For thousands of years men have been falling off their two-story dwellings and out of trees, where the fall is about 20 ft. It is possible to survive this impact, although it is just about the "shock limit" for the human body. Thus it was appropriate to call this quantity of energy which each pound of the body and each pound of the car carries at 25 mph, "one danger unit of energy." At 35 mph, the blows are twice as heavy. At 75 mph, they are nine times as heavy.

In other words, the danger unit is mathematically equal to the energy developed in an automobile moving at 25 mph, to a street width (35 to 40 ft) of actual stopping distance, to one "roll-over" in case of an accident, or to an 80-ft turning radius on a curve. The rate of speed and the relative danger units, therefore, are 25 mph for one D. U., 35 for 2, 45 for 3, 50 for 4, 55 for 5, 60 for 6, 65 for 7, 70 for 8, 75 for 9, and 80 for 10. In this way it is easy for a driver to visualize that at 50 mph he will need four street widths to stop, he will roll over four times in case of an accident, or make one fourth as sharp a turn as he could at 25 mph or one danger unit.

McDonald Observatory

UNIVERSITY OF TEXAS

THE McDONALD OBSERVATORY together with its 82-in. reflecting telescope, which was constructed by the University of Texas from the proceeds of a trust fund amounting to $800,000 left by the late William J. McDonald, has just been completed and will be formally dedicated on May 5. Perched nearly 6800 ft on top of Mt. Locke in the Davis Mountains in western Texas, the observatory will be operated jointly by the University of Texas and the University of Chicago, which now operates the Yerkes Observatory in Williams Bay, Wis. The telescope is the second largest reflector type in actual use in the world. It is exceeded in size only by the 100-in. instrument at Mt. Wilson. Both of these will be topped at some future date when the 200-in. Palomar telescope is completed.

The contract for both the design and construction of the observatory and the telescope was let in 1933. The observatory structure was completed last year and the 3-ton, 82-in. mirror, in February, after four years of grinding and polishing.

The observatory itself is a cylindrical steel structure, 71 ft

FIG. 1 VIEW OF 82-INCH REFLECTOR TELESCOPE IN THE MCDONALD OBSERVATORY LOOKING DOWNWARD

(Scales shown indicate variations from the vertical. Inside lower part of telescope may be seen, in closed position, the shutter which covers enclosed part of telescope, at the bottom of which the mirror is mounted. Weights shown at top and bottom of telescope are delicate counterbalances.)

high, surmounted by a hemispherical dome, 62 ft in diameter. The observing floor, on which the telescope stands, is three stories above the ground. The two lower floors contain offices, chemical kitchen, library, developing rooms, sleeping quarters, instrument shop, and a collection as a memorial to the donor of the observatory. In the 115-ton dome is an 18-ft-wide rectangular opening, extending from the base of the dome to its zenith, through which the telescope will be sighted. A description of the dome and its operating mechanism was given by E. N. Jennison in an article beginning on page 349 of the June, 1935, issue of MECHANICAL ENGINEERING.

Because of the 26-ft length of the telescope, it has been necessary to provide observing positions at any point, no matter which direction the telescope is pointed. A lower observing position consists of two movable platforms which can be raised or lowered, as desired. Upper observing positions are provided by an elevator-type observing bridge, suspended from the dome. On the bridge are all of the controls needed to raise or lower the bridge, alter the position of the telescope in any direction, revolve the dome, open or close the shutter, or raise or lower the wind curtains. Some $5^1/_2$ miles of electric wiring were required for the intricate control system.

The 82-in. mirror, which is part of the telescope, is 13 in. thick and weighs nearly three tons. It was cast of Pyrex glass by the Corning Glass Works on Dec. 31, 1933. After cooling for several months, it was brought to the optical department of The Warner & Swasey Company for grinding, polishing, and aluminizing. After four years of grinding and polishing, during which time the curved surface of the mirror reached a maximum depth of $1^1/_3$ in. and the curve itself was made accurate to one millionth of an inch, the mirror was placed in the aluminizing cell, in which a vacuum had been created, and where aluminum and chronium atoms were shot against the face of the mirror to form the reflecting surface. In addition to the 82-in. mirror, five secondary mirrors will be used, two each for the Cassegrain and three for the Coudé focus.

The telescope is mounted upon two massive piers, known as the south and the north pier. Some 450 tons of concrete and 10 tons of reinforcing steel were used in their construction. Between these two piers extends the axis of the telescope, known as the polar axis because it is exactly parallel to the axis of the earth. So carefully is the 26-ft, 75-ton instrument balanced that it is driven by a $^1/_8$-hp electric motor and focused to a hair's breadth. This motor-driven right ascension control is used to counteract the effect of the earth's rotation and to hold the lens in constant focus. A total of 30 motors is required to operate the observatory.

Fretting Corrosion

THE INSTITUTION OF MECHANICAL ENGINEERS (GREAT BRITAIN)

CORROSION at the contact surfaces of closely fitting machine components, when subject to vibration, has long been a source of considerable trouble in many branches of engineering practice, especially in aeronautical and automotive engines. This corrosion must be distinguished at the outset from ordinary wear by the fact that it always occurs at contact surfaces which are for all practical purposes fixed in relation to each other. A very common example is a ball race housing, which is a press fit on the shaft. On removing such a component it is frequently found that the fitting surfaces, originally highly finished, are corroded and pitted in irregular patches, and usually a quantity of colored oxide débris is to be seen. The appearance of the damaged areas on one of the surfaces is generally almost identical with that on the other surface, showing conclusively that the component has moved during the process. Other common examples from practice include spline fits, shafts and hubs of keyed gears, engine bearings, collets, etc. Even force and shrink fits may be subject to this destructive action, as shown by the brownish slime, composed of oxide débris and oil, often seen oozing from the junction of the surfaces.

Very little literature exists concerning fretting corrosion, which is unlike ordinary corrosion in that it only occurs when the machine is operating, and in contrast to the kindred subjects, wear and lubrication, there is surprisingly little knowledge of this subject. Quite recently J. C. Almen (MECHANICAL ENGINEERING, June, 1937, p. 415) investigated the fretting of ball and roller bearings in a very practical manner and, from the results, attempted to assess the relative values of a large range of lubricants as protective coatings. This year, at a meeting of The Institution of Mechanical Engineers on March 3, a report was made of an investigation of fretting corrosion carried out at the National Physical Laboratory (Great Britain) by G. A. Tomlinson and P. L. Thorpe, of the Laboratory, and H. J. Gough, director of scientific research for the British War Office. In view of the little known about the subject, one object of the experimenters has been an experimental study of the conditions leading to fretting corrosion, and in this direction some information has been acquired, although a complete explanation of the phenomena cannot yet be suggested.

There is ample evidence, both in the experiments described in the paper and from practical experience of the authors, that the ***primary*** cause of fretting corrosion is of a mechanical rather than chemical nature. In practice it is well known that ma-

chine components only corrode in this way in the presence of vibration. However, the experiments have shown that vibration alone is not sufficient, and that alternating surface stress alone will not produce corrosion. There must be some to-and-fro surface slip and there is good evidence that it is the alternating character rather than the amount of slip that is the important factor in causing corrosion.

Assuming the process to be mechanical, the first explanation of the corrosion that suggests itself is that it is simply a mechanical grinding or abrading effect. There are, however, some good reasons for regarding the corrosion to be due to attrition of the surfaces on a molecular scale and these will be considered briefly. A decision on this question is considered to be of some importance as it places the corrosion phenomena in one of two classes of physical properties of metals. In one class are the molecular properties, such as elasticity, friction, thermal expansion, etc., and in the other class are the structural properties, such as tenacity, hardness, brittleness, etc. A point of distinction between these classes is that the latter properties can be controlled within wide limits by suitable treatment of the material, but the molecular properties cannot be altered substantially.

Considering first the effect of the normal pressure intensity, it was seen that the corrosion is not greatly different over a range of normal pressure from about 26 to 3 tons per sq in. Corrosion therefore appears to occur with little regard to the magnitude of normal pressure. This is not easily reconcilable with the mechanical-abrasion view but is quite consistent with the molecular-attrition theory. The cohesive forces of molecules are intrinsic and independent of external forces and only require sufficiently close proximity to become effective.

The cases of corrosion with excessively small amounts of slip point to the same conclusion. It is hardly conceivable that a movement so small as 5×10^{-8} in., or only about four times the atomic dimensions, can give rise to bodily abrasion. The smallness of the movement, on the other hand, presents no objection to the molecular theory, which only requires displacements comparable with the dimensions of the molecular field of force.

Another argument for the molecular theory and against the abrasion theory is in the well-known fact that this kind of corrosion becomes more effective the more highly the surfaces are finished. This does not support the abrasion view but is entirely consistent with the cohesion theory as demonstrated, for example, by the direct contact cohesion of highly finished glass or silica surfaces.

The surface elasticity can be explained in a general way as an effect of surface cohesion. When two solids are in contact and are exerting a normal pressure, some proportion of the surface atoms must have approached close enough together to be under mutual repulsion. At this distance there is little doubt that they are within the range of the field of attraction. There are then numerous salient points on the surface where the bodies are linked by atomic bonds. If the surfaces are displaced relatively in a tangential direction the chains of bonded atoms are first distorted and then broken. The distortion can be regarded as the source of the surface elasticity. The conception of the breaking of the atomic bonds in the theory corresponds to the observation of the slip in the experiments, and as it has been proved that corrosion is definitely associated with slip it is reasonable to assume the attrition of the surface to be caused in some way by the severance of cohesion bonds.

However, the foregoing must not be read as to exclude the possibility of some special type of *fatigue* action as the responsible mechanism of failure. In fact, repeated straining of the contact surfaces has been shown to be essential to the marked deterioration which is the serious practical problem. But whereas the term "fatigue" usually denotes progressive deterioration by cyclic straining of the metal as a whole, the present action is confined to surface layers in close contact. For this reason and until the actual mechanism is more clearly understood, it appears desirable to denote the present action by the term "fretting corrosion," recognizing that time may show it is a special case of the larger subject of fatigue. In fact the recent studies of fatigue carried out at the National Physical Laboratory, using precision X-ray methods, reveal a process which is so essentially a progressive straining and rupture of atomic bonds as to present many parallel aspects with fretting corrosion.

The results of the investigation are not as encouraging as would be desired with regard to means for the alleviation or elimination of the practical difficulties arising from fretting corrosion. Without any exception corrosion has always occurred in the presence of surface slip and, to eliminate slip of the magnitude found to be effective, is not an easy problem. If the theoretical conclusions stated are valid, the corrosion must be placed in the class of molecular phenomena and as such may have to be regarded as being inevitable like cohesion or friction. Nevertheless, much new information has been gained from the tests described, the results of which may form the basis of a useful discussion as to possible means of reducing the service problem and with regard to further laboratory investigation.

High-Speed Cutting Tools

THE INSTITUTION OF PRODUCTION ENGINEERS (GREAT BRITAIN)

A REVIEW of the results which have been arrived at during the last five years concerning the manufacture and use of high-speed cutting tools is given by Georg Schlesinger, member A.S.M.E., and director of the new research department of The Institution of Production Engineers (Great Britain), in a paper published in the February, 1939, issue of the journal of the Institution. Dr. Schlesinger is well known for his researches in machine-shop practice, and his views on the subject of high-speed cutting tools are therefore of interest.

The three demands on modern machine tools, says Dr. Schlesinger, are speed, accuracy, and long life, i.e., economy for the user. The satisfying of these demands depends not only on the tool but on the resistance of the material to be machined, its tensile strength, hardness, and toughness. Increase in resistance of the material is finally reflected back to the machine tool, which must be designed for greater power and speed and manufactured more accurately. Attempts to speed up old machines to make possible the utilization of high-speed tools must be made carefully, as many breakdowns may occur which would outweigh the benefits.

The superrapid steels as well as the cemented carbides are now used for all cutting tools. In outward appearance there is no difference between a cemented-carbide and a cobalt-tungsten tip. The manufacture and treatment of these tools by brazing, welding, hardening, tempering, grinding, lapping, honing, and diamondizing, are very similar and can be discussed together. The only difference which exists is that high-speed steels can be butt-welded instead of having the tips brazed on the shanks. Butt-welded cobalt-tungsten tools make contact with the grinding wheel with uniform material, whereas tipped tools need special grinding precautions, as the shank of mild steel and the tip of high-speed steel in combination will easily glaze a grinding wheel selected for the tip or wear it down rapidly. The welded tool is superior in strength and will, in most cases, undergo more regrindings before being discarded.

Almost the whole of the high-speed tool portion may be ground away leaving only the shank material. With regard to the strength of the butt weld in these tools, tests to destruction have proved that the weld shows greater strength than the high-speed end of the tool.

Tips may be brazed to shanks made of high-grade steel, usually containing 0.4 to 0.7 per cent carbon. Pure copper is employed as the brazing medium and the flux suggested is unfused borax. The copper should be melted rapidly and the temperature of the furnace should then be maintained at 2100 to 2300 F with a reducing-hydrogen atmosphere. Every precaution should be taken to make sure that the flame does not impinge directly on the tip. It is advisable to preheat the shank to 1500 F. The tip must have a good fit in its seat. Both shank and tip must be degreased; carbon tetrachloride is recommended and gasoline is not. When the copper starts to liquefy, the tip is moved slightly on its seat to make sure of a satisfactory joint. After this the tool should be removed from the furnace, the tip gently pressed into place, and the brazed tool dipped in powdered charcoal to make possible slow cooling without contact with the air.

Wet grinding of the tool is recommended and should be carried out with extreme care. Coolant must be supplied plentifully and constantly. Good compositions of coolants are mixtures of a mineral oil with a sulphurized fatty oil; 20 per cent saponifiable oil, 1.8 per cent total sulphur, and 78 per cent mineral oil. To minimize the risk of chipping, the tool should be ground from the tip to the body of the tool, the front and side faces being ground first, and lastly the top. Only moderate pressures should be used in grinding. The application of undue force results in rapid wheel wear with the possible cracking and chipping of the cutting edge of the tool. Therefore, hand grinding is recommended with the use of rest and angle fixtures.

Ordinary emery grinding wheels with peripheral speeds of from 4000 to 6000 ft per min are used for wet-grinding cobalt-tungsten tools. To grind cemented-carbide-tipped tools, generally two and frequently three operations are used, roughing, finishing, and fine-finishing. For roughing the tip a soft carborundum wheel (green crystolon) with plenty of water is used. Finish-grinding is carried out on specially graded wheels. Final finishing should be effected with diamond wheels. Diamond grinding of the cutting edge is absolutely essential for tools which are intended to cut synthetic resins, insulating materials, and for any finishing operations. It is not recommended that diamond grinding wheels be used for rough-grinding. Peripheral speeds between 3600 and 5500 ft per min are employed.

The use of cemented-carbide-tipped tools requires a certain amount of care in order to prevent vibration and consequent breakage. The rules may be summarized as follows: (1) No irregularity of the feed is permissible. Rack and pinions allow some play, consequently screw and nut feeding mechanisms are preferable. (2) The tool must be firmly supported as near to the cutting edge as is conveniently possible. (3) There must be no chatter or vibration in either the machine itself or the piece being machined. (4) There must be no end movement or lift in the main spindle bearings. (5) The driving belt or motor must provide sufficient power without any slippage of belt or clutch. The least stoppage of the workpiece breaks the tool. (6) When used on planing machines the toolboxes should be provided with a positive lifting device to clear the tool during the return stroke.

The shape of the chip depends primarily on the cutting speed. The three types of chips are tear-type, shear-type, and flow-type, each of which may be distinguished by the effect on the surface. By avoiding the built-up edge, which is always tearing, a good result will be obtained. In cutting steel, high speed and good lubricants are the two best remedies for rough surface finish. Experiments show that there is no built-up edge at peripheral speeds of 300 ft or more.

The diamond single-point tool has been used for more than thirty years for machining nonferrous metals and alloys, such as copper, brass, bronze, white metals, aluminum, silver, gold, platinum, ebonite, and various plastics. For steel and cast iron the working conditions must be exceptionally good for diamond tools to be used to advantage. Only superfine finishing work can be carried out with diamond tools having feeds from 0.0004 to 0.004 in. per revolution and a cutting depth from 0.008 to 0.24 in. Both depend upon the cutting resistance of the material to be machined. The surface speed ought to be not less than 600 ft per min, and on large diameters, i.e., copper slip rings, commutators, etc., speeds over 10,000 ft per min have been employed. In area the chip section varies from 0.0000064 to 0.00016 sq in. The life of the diamond tool may be between 100 to 200 working hours if speed, feed, and depth of cut are correctly selected and the tool is well treated. Good working conditions are: (1) Cold-set diamond tool; (2) micrometer means of adjustment; (3) easily readable gages; (4) means for securely retaining the diamond tool when performing heavy cutting operations; (5) provision for replacement of the diamond tool without disturbing the adjustment; (6) a rigid machine tool; (7) very rigid toolholder and secure clamping in tool post; and (8) every trace of vibration must be avoided. Following these rules will make it possible to maintain working tolerances of 0.00008 with a very fine surface finish surpassing that of a fine-grinding action.

The diamond hand lap is a very useful tool to stone the cutting edges of cemented-carbide tips, if roughing down pieces of steel on the lathe. This hand lap consists of a flat piece of bakelite either impregnated with or having a layer of diamond dust on the surface. A good quality of thin oil should be used when lapping. The tool is stoned without disturbing the machine at frequent intervals to preserve the cutting edge.

Utilizing Solar Heat

SMITHSONIAN INSTITUTION

REPORTS are frequently heard of attempts and proposals to utilize the energy of the sun for h eating and power. Among recent investigators of this subject is C. G. Abbot, secretary of the Smithsonian Institution, Washington, D. C., who, in 1936, demonstrated at the World Power Congress his solar boiler for a one-half-horsepower engine. Dr. Abbot has built many solar-energy devices, and in publication 3530, Smithsonian Miscellaneous Collections, Vol. 98, No. 5, "Utilizing Heat From the Sun," he describes some of his boilers, water distillers, and cookers.

According to Dr. Abbot, we may count on the possibility of converting 15 per cent of the energy of such solar rays as are intercepted by our devices into mechanical work. Assuming that to avoid appreciable losses through shading one unit by another and, to allow plenty of room for other purposes, only one tenth of the area is actually covered by heat collectors, and further allowing for night and cloudy weather, still, he points out, the State of New Mexico could supply from solar radiation over ten trillion horsepower-hours per year of mechanical power, which compares with the power possibilities of all coal, oil, and water at present used annually for heat, light, and power combined in the United States.

Because of the intermittent availability of sunlight, means of storing the captured solar energy for use at night and in cloudy

weather are clearly necessary, and several methods are proposed. One of these, suggested by Dr. Cottrell, is a mass of coarse dry sand, thoroughly insulated, into which, by means of suitable piping, hot air from the heater is introduced. From the heated sand the stored energy may be withdrawn at will in the form of hot air. Other storage means are: electric storage batteries; chemical storage by electrolyzing water and saving the hydrogen to be burned as fuel for generating steam; mechanical storage, in the form of water pumped to an elevated reservoir; and thermal storage by means of an accumulator in which water is heated above the boiling point.

Dr. Abbot's apparatus for capturing solar energy is simple in principle. Briefly, a tube through which a heat-absorbing medium is circulated is held parallel to the earth's axis in the focus of a parabolic cylindrical mirror set so as to face into the sun's rays and actuated by a clock to keep pace with the sun's movements. The cheap production of efficient solar-heat devices, he says, has awaited the commercial development of aluminum products and the common use of vacuum devices. The heavy, costly, and nondurable glass mirrors formerly used by inventors have been replaced by reflectors of Alcoa in thin sheets which readily take the curvature of a suitable cradle form without previous shaping. This material reflects over 80 per cent of solar radiation and may be used for years without dimming. As the loss of heat in the boiler at the focus of a solar-radiation device is the great obstacle to be provided against, the possibility of making cheap glass jackets enclosing high vacua like thermos bottles is the other great improvement of recent times.

In recent installations of a solar cooker Dr. Abbot says he has used "arochlor," a nearly black liquid product, made completely absorptive by adding a small amount of lampblack in suspension. This liquid, which does not boil below 350 C, may be used directly in a vacuum-jacketed glass focus tube. Dr. Abbot also describes solar water-distilling devices, and a solar flash boiler for power, equipped with an automatic regulator. Computations of the efficiency of a solar flash boiler are found in Table 1.

TABLE 1 EFFICIENCY OF SOLAR FLASH BOILER

A	Efficiency of the boiler, assumed temperature 190 C	
	Mirror reflection, per cent	82
	Transmission by vacuum jacket, per cent	85
	Absorption by boiler tube, per cent	95
	Loss of heat through the jacket, per cent	10
	Boiler efficiency (0.82 × 0.85 × 0.95 × 0.90), per cent	60
B	Thermodynamic factor for perfect engine	
	Assumed temperature of condenser, C	30
	Efficiency factor $\frac{190 - 30}{190 + 273}$, per cent	34.5
C	Mechanical efficiency of engine (assumed), per cent	75
D	Final result. Efficiency of conversion of solar to mechanical energy: (0.60 × 0.345 × 0.75), per cent	15.5

As to the commercial use and cost of solar heating, Dr. Abbot has the following to say:

It is probable that so long as coal is cheap and abundant there will be no extensive use of solar power. However, small installations, in 2- to 5-hp units, may become profitable under favorable conditions. Solar heat has already been used successfully for refrigeration, and possibly might be combined with a heating system for conditioning the air in ranch propositions in cloudless regions. The classic use of solar power is, of course, for irrigation, and here the problem of storage is not important. It is conceivable that great reservoirs might be pumped full of water from rivers or lakes by solar power in dry years to irrigate land when rains fail.

Both solar cooking and solar distilling of nonpotable water are practical and efficient propositions, which will likely be in common use before very long if the necessary outfits can be produced at attractive prices. The cost of solar devices, as of all other products, depends greatly on the volume of sales. These devices, however, as compared with automobiles, are extremely simple. Though it might cost prohibitively to produce them singly, I think not if produced in thousands.

New Specific-Heat Equations

STATE ENGINEERING EXPERIMENT STATION, ATLANTA GEORGIA

Application of spectroscopic analysis in recent years has produced a wealth of data on specific heats. These values of specific heat, as illustrated in Fig. 2, differ from those now

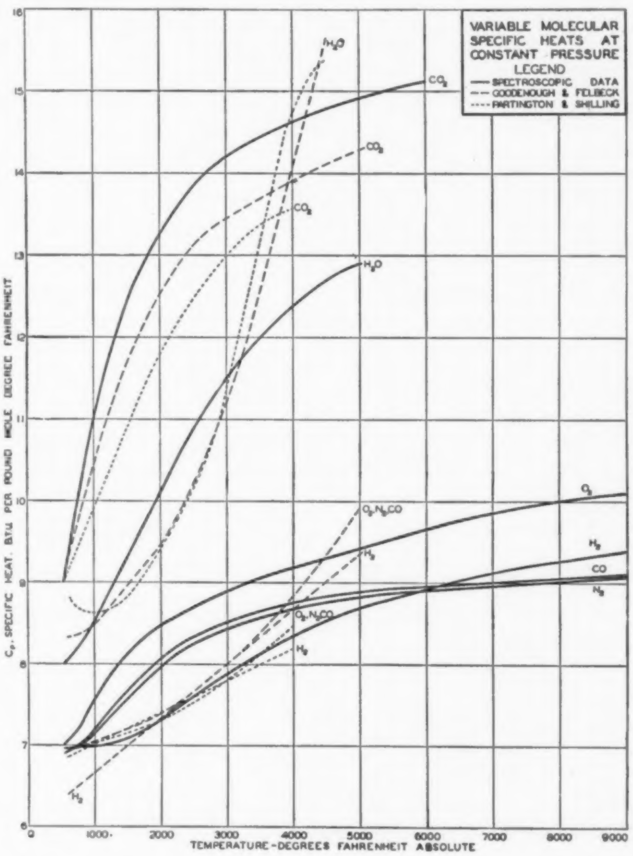


FIG. 2 VARIABLE MOLECULAR SPECIFIC HEATS AT CONSTANT PRESSURE

employed in engineering practice. In order that the values of specific heat determined from spectroscopic data might be used, empirical equations were developed by Ray L. Sweigert, member A.S.M.E., and M. W. Beardsley, and published under the title of "Empirical Specific Heat Equations Based Upon Spectroscopic Data," Bulletin No. 2, State Engineering Experiment Station, Atlanta, Georgia.

Since the type of equation and statistical summation used in the calculations of specific heats from spectroscopic data were too complicated for use in ordinary engineering computations, the authors decided to use empirical equations. The following criteria for setting up the equations were established.

1 The equations should represent the spectroscopically determined variable specific heats with a maximum error of 2 per cent.

2 The equations should have a simple form to facilitate

TABLE 2 EMPIRICAL SPECIFIC-HEAT EQUATIONS BASED UPON SPECTROSCOPIC DATA

Gas or Vapor	*Equation*	*Range*	*Max. Error*
	C_p in B.t.u./lb. mole °F.	°R.	%
O_2	$C_p = 11.515 - \frac{172}{\sqrt{T}} + \frac{1530}{T}$	540-5000	1.1
	$= 11.515 - \frac{172}{\sqrt{T}} + \frac{1530}{T} + \frac{0.05}{1000}(T-4000)$	5000-9000	0.3
N_2	$C_p = 9.47 - \frac{3.47 \times 10^3}{T} + \frac{1.16 \times 10^6}{T^2}$	540-9000	1.7
CO	$C_p = 9.46 - \frac{3.29 \times 10^3}{T} + \frac{1.07 \times 10^6}{T^2}$	540-9000	1.1
H_2	$C_p = 5.76 + \frac{0.578}{1000}T + \frac{20}{\sqrt{T}}$	540-4000	0.8
	$= 5.76 + \frac{0.578}{1000}T + \frac{20}{\sqrt{T}} - \frac{0.33}{1000}(T-4000)$	4000-9000	1.4
H_2O	$C_p = 19.86 - \frac{597}{\sqrt{T}} + \frac{7500}{T}$	540-5400	1.8
CO_2	$C_p = 16.2 - \frac{6.53 \times 10^3}{T} + \frac{1.41 \times 10^6}{T^2}$	540-6300	0.8
CH_4	$C_p = 4.52 + 0.00737\ T$	540-1500	1.2
C_2H_4	$C_p = 4.23 + 0.01177\ T$	350-1100	1.5
C_2H_6	$C_p = 4.01 + 0.01636\ T$	400-1100	1.5
C_8H_{18}	$C_p = 7.92 + 0.0601\ T$	400-1100	est. 4
$C_{12}H_{26}$	$C_p = 8.68 + 0.0889\ T$	400-1100	est. 4

their employment, which in turn should entail the use of nothing more than a slide rule.

3 The equations should be comprehensive enough so that one equation for each gas would cover the entire range of temperatures from 540 R to 5000 R.

4 The equations should employ engineering units, i.e., Btu, the poundmole, and degrees Rankine.

The data from which the equations were developed were obtained from sources of generally recognized authenticity. Since the conventional type of expression could not be adapted to the spectroscopically determined specific heats, a new type of equation was developed by the authors. It is based upon the theoretical energy distribution within the molecule and is of the form

$$C_p = a - \frac{b}{T} + \frac{c}{T^2}$$

This type of equation fits the spectroscopic data satisfactorily for temperatures above 540 F abs in the cases of N_2, CO, and CO_2, although a modified type

$$C_p = a - \frac{b}{\sqrt{T}} + \frac{c}{T}$$

is more accurate for O_2 and H_2O. In Table 2, these equations are worked out with numerical values for O_2, N_2, CO, H_2, H_2O, CO_2, CH_4, C_2H_4, C_2H_6, C_8H_{18}, and $C_{12}H_{26}$. Since these equations meet the criteria set up for them and accurately follow the original data over the range of temperature for which data are available, the authors feel that they should prove useful to engineers.

Tailless Airplane

THE AEROPLANE

ACCORDING to an article in the March 15, 1939, issue of *The Aeroplane*, specifications for a two-engine tailless monoplane are set forth in a British patent granted on Jan. 2, 1939, to Handley Page, Ltd., and Gustav V. Lachmnan. The drawings in the patent application, illustrated by Figs. 3 and 4, show a streamlined fuselage to which is attached the main wings. The center sections of the wings carry two in-line engines which drive pusher-type propellers. The swept-back outer portions of the wings carry rudders at their tips.

However, the basis of the patent is the two auxiliary airfoils mounted in front of and slightly above the leading edge of the rectangular section of the wings. These airfoils are arranged to maintain longitudinal trim for the whole airplane whatever the incidence of the main wings. They are not elevators but are there to counteract the large changes of longitudinal trim inherent in tailless designs, particularly those with flaps.

The idea of auxiliary airfoils in front of the main wings is not new in its broad essentials. There have been tail-first airplanes with a front stabilizing surface which has had elevators attached. There have also been airplanes which have had auxiliary airfoils differentially operated for lateral control. But the new Handley Page-Lachmann design is in no wise concerned with any of these. They are, in the words of the patent application, "solely forwardly located auxiliary airfoils serving as a longitudinal trimming device for a tailless aircraft having stable main wings, which airfoils are controllable by the pilot when it is necessary to alter the trim of the aircraft to vary the angle of incidence at which the auxiliary airfoils will float and hence the pitching moment which they will exert."

Longitudinal stability is achieved as shown in Fig. 4. In

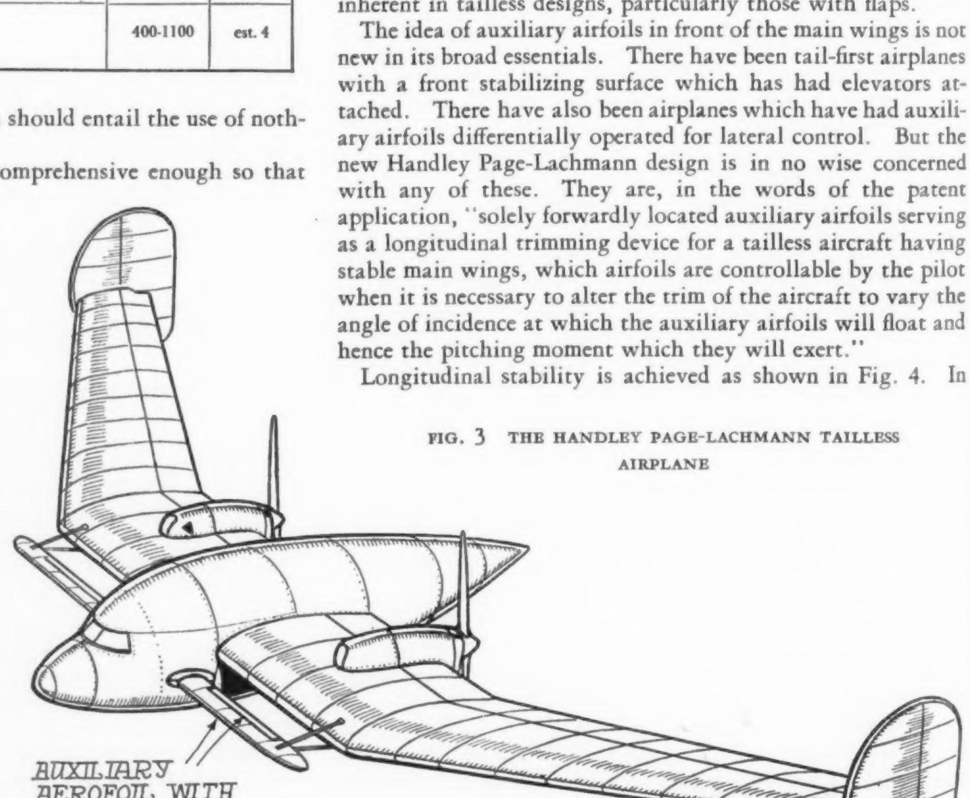


FIG. 3 THE HANDLEY PAGE-LACHMANN TAILLESS AIRPLANE

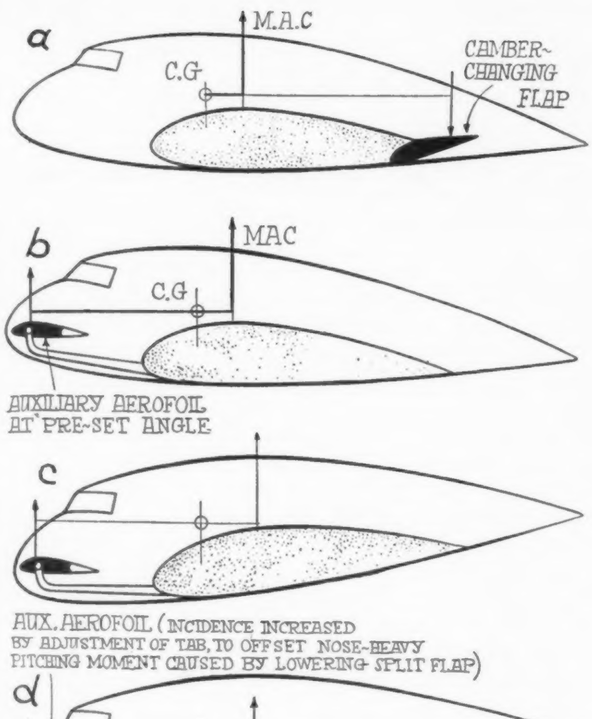


FIG. 4 HOW LONGITUDINAL STABILITY IS ACHIEVED IN AN ORDINARY TAILLESS AIRPLANE AND IN THE HANDLEY PAGE-LACHMANN TYPE

(*MAC* = mean aerodynamic center of main wing, and *CG* = center of gravity of airplane.)

the ordinary tailless design, *a*, the nose-heaviness necessary for stability is counteracted by turning up the trailing edges. In the new Handley Page-Lachmann design, *b*, *c*, and *d*, the necessary nose-heaviness is countered by auxiliary airfoils in front of the wings. They are mass-balanced and free to float, and of such area that they supply enough lift at their normal position to counteract nose-heaviness whatever the position of the airplane. To counter sudden increases of nose-heaviness, such as that caused by pulling down split flaps, the angle of the auxiliary airfoils, and, consequently, their lift, can be increased by the pilot or automatically by coupling them to the flaps.

Engineering Schools and Unions

THE JOURNAL OF ENGINEERING EDUCATION

IN VIEW of the comments offered editorially last month on the subject of youth and organized labor, it is appropriate to present the following excerpts from an address "Engineering Schools and Unions," delivered some time ago by V. T. Bouton, managing editor, *Engineering News-Record*, and published in the March, 1939, issue of the *Journal of Engineering Education*. Mr. Bouton said in part:

The first essential to a study of the union movement is to recognize that there is nothing fundamentally wrong in a trade union. A lot of engineers do not hold to that view; they maintain that professionalism and unionism are incompatible. When analyzed this view is found to be mostly wishful thinking. It finds its origin in the natural revulsion of the educated man to trade unions as we know them today and to the tactics of union organizers.

Yet the purpose of a trade union is laudable. It is to get for its members by collective action what the individual cannot get alone. Our state professional societies have much the same purpose, but employ different methods. So far they have limited themselves chiefly to legislative matters and civil-service questions, but in New York State the state society has taken a hand in getting better pay for engineers on WPA, a move, by the way, in which the A.S.C.E. cooperated. There is no reason why, ultimately, the state societies might not represent employees in collective bargaining with employers. Developed from that angle, you would have the ideal union with few objectionable features . . . .

As pay rates and working hours are the chief concern of unions, it is essential that all men included in the union be classified as to work done and pay. And once a man finds himself in a particular group he finds also that about the only way to get out of that group is by the slow process of seniority. The older man, regardless of ability, gets the preference unless he actually lacks the technical qualifications. Of course we have much the same situation in civil service except that major changes now are made on the basis of examination. Then there is the tendency in large groups to check the production of the ambitious worker to keep him from showing up the rest of the group, a leveling process which is one of the chief drawbacks for the ambitious man in any regimentation . . .

Turning now to your particular problem, what do the technical unions have to offer to the engineering graduate? I think they have little to offer except to the man who finds himself one of many engineers employed by a large corporation. To these men, temporarily at least, union membership may be an advantage. Certainly I would not advise the young engineer going into a big corporation where the engineers are already unionized to hold aloof. He might better join the union and throw his weight with those who would raise the union's standards. Also, an engineers' union in such an organization has the desirable effect of keeping engineers together as a separate bargaining agency. Without a union in a highly unionized plant they are swallowed up in a big company union. . . . .

Your students should be shown both sides of the picture. Blind following of the idealist, who tells them that the only way to high professional position is to avoid the unions, will lead to just as much disillusionment as will blind following of the labor organizer who promises high pay and easy working conditions.

No one can deny that young engineers and engineering assistants have been and still are exploited through low pay and long hours. Even some of the most ethical leaders of our profession have not been above exploitation under the guise of giving the young man practical experience. The unions have helped materially in checking this practice, which was particularly bad among speculative builders in New York a few years ago. The Wagner Labor Relations Act and the new Fair Labor Standards Act, both fostered by organized labor, have done much to spread the gains and make them permanent—bad as both acts are in other respects.

Curious as it may seem, the labor-relations act and the fair-labor-standards act may prove to be the end of smaller unions like the technical unions because once the principle of collective bargaining is widely accepted by employers, and once the small groups of employees realize that even they can appeal directly to the NLRB if need be, there will be little reason to pay dues to support national officers and to pay national organizers . . . .

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Industrial Price Policies and Economic Progress

To the Editor:

The Brookings Institution has recently published a book,[1] "Industrial Price Policies and Economic Progress," by Edwin G. Nourse and Horace B. Drury. This book is divided into eleven chapters to which are added five appendixes. The first two chapters are intended to give a bird's-eye view of the subject. The second group of chapters, numbers three to seven, inclusive, is intended to present an analysis of practical concrete aspects of recent industrial price making and describes various ways in which reduction in real price has been effected in many parts of the industrial field in recent decades. The third part of the book, chapters eight to eleven, attempts to deal with the organizational factor and the various ways in which the specialized executive function may be exercised through price policy to determine the course of modern industry.

The directors' preface points out that the book, "seeks to discern the constructive implications of what is already being done by pacemakers in this field and to envision the results to be expected if these constructive lines of business practice were widely followed." It also points out that the book is, "not directly concerned with the present depression or with depression causes or cures."

In view of this statement it is interesting to note these remarks in the final chapter. "What type of price adjustments are needed to cause our economic system to function so perfectly that, out of maximum product, stockholders of corporations as well as all other participants may derive the largest return which can be continuously maintained by the productive process?" One is almost inclined to say, "Hallelujah!" after reading a question like this. The answer is as follows: "The only answer to this question that we are proposing is that given by those businessmen who have accepted the challenge of finding ways of organizing production so as to supply wants within the purchasing power of the workers who produce the goods." Let us now say, "Amen."

The whole book is a keen disappointment. First, it is not a scientific inquiry as it purports to be, but is written in praise of the present economic system and the entrenched privileges in that system. The book, as the authors say, is written from the point of view, "that other writers have dealt or will deal with the question of capital's share or of labor's share in the benefits accruing from increased productivity . . . . . . we are limiting ourselves to a study of the process by which dissemination to all parts of the population may be effected through price adjustment and the repercussions that this distributive process has on production itself."

Since one of the most important problems in this whole matter is the relative claims of capital and labor to the goods produced we cannot understand how the neglect of this relationship in any so-called scientific study can give any answer to the problem of "the process by which dissemination to all parts of the population may be effected through price adjustment."

The authors state that they are considering only "administered" prices, that is, prices established by the decision of the executives who have power to decide in advance the price at which goods shall be sold. They also say that, "in the absence of such power to influence the market there would be no question of price policy to discuss." The inquiry then narrows down, as expressed by the authors, to "the pertinent question is whether this power of the executive to guide the course of prices is exercised with such intelligence as to promote economic progress to the full." The authors use up a great deal of space in the book in describing how these wise executives have proposed to adjust these prices and they come out in the final chapter with the answer previously given, which implies that these wise and courageous businessmen are to be let alone to adjust prices as the best way to solve this problem. We were always under the impression that a scientific inquiry was based on the establishment of units, means, and methods of measurement. We find absolutely nothing to support this belief in this book. How one can draw such a conclusion after supposedly scientific inquiry is beyond my understanding. The authors give no data in support of this conclusion.

Another good example of scientific reasoning is the statement on the last page of the book, "It is the distinctive achievement of capitalism that it has made available more efficient techniques and equipment to the labor force." It is well to remember that two events coincident in time are not necessarily cause and effect.

As the writer understands capitalism, it is that world-wide system of production and trade through which private enterprise seeking profit and fortune hires for wages the mass of human labor. It occurs to the reviewer that these more efficient techniques and equipments arose from the efforts of the scientist and the engineer. It was the work of Professor Hall that created the more efficient technique and equipment of the great aluminum industry. The authors do state, "it has been its (capitalism's) chief shortcoming that it has not fully succeeded in finding ways of administering the pecuniary part of the system so that labor shall be able at all times to apply itself as fully as it wishes to the satisfaction of its wants." And then follows the startling answer. "But if this more courageous and imaginative type of price making can be generalized, this limitation upon capitalistic production will disappear." But there is no evidence to support this conclusion.

One of the difficulties with our eco-

[1] Another review of this book, one of the series of reviews prepared monthly by the department of economics and social science of the Massachusetts Institute of Technology, appeared in the March issue, page 226. Professor Rautenstrauch presents a different point of view on the book, and includes comments in his own vigorous style that are interesting on their own account. Because his review was received after Professor Freeman's was in type, he has consented to let it appear as a "letter to the editor." Professor Rautenstrauch's review was prepared independently before Professor Freeman's was published, and is a review of the book and not a comment on the review in the March issue.—Editor.

nomic system is that our production and distribution systems are not properly matched for normal continuous operation. Our boiler is twice the capacity of its outlet pipes, there is no satisfactory permanent safety device, and it is extremely difficult to shut off or dampen the fire under the boiler, once it has been kindled. Such inefficiency would not be tolerated in an engineering design of a boiler installation, but because we have not matured to the point of associating efficiency with our economic system or of subjecting ourselves to the discipline necessary to efficient operation, our economic system remains in the state of sporadic growth. We can either attempt to content ourselves with "laissez faire" operation as Nourse and Drury suggest, with its accompanying cycles, booms, depressions, peace eras, and wars ad infinitum, or we can turn our efforts to the intelligent redesign of the economic system so as to remove the causes of these cataclysms and perfect an efficient mechanism continuously operating smoothly, and it is perfectly possible to do this within the constitutional limits of this country.

The engineering profession is founded on the fact that merely rationalizing about some phenomena does not cause the problem accompanying those phenomena to disappear. Progress is made and practical problems solved successfully only when the rationalization process is refined to a postulate; the postulate tested and accepted, rejected, or modified according to the results; and the problem accompanying the phenomena rectified accordingly. Nourse and Drury attempt to accomplish only the first step, and consequently their contribution to progress in solving our economic problems is negligible. The Nourse and Drury treatise on prices becomes, as do the majority of prior Brookings Institution publications, a convenient case-book collection of heterogeneous experiences of various enterprises within our economic system. The book is "safe" and "acceptable" from the point of view that no constructive criticisms are rendered, merely the recitation of "cases" with benefit of a very few conclusions, at which any keen engineer has in all probability already arrived. The material is presented in such sequence and in such a manner as to furnish timely brief for the status quo in connection with the current investigation of the Temporary National Economic Committee.

The first eighty-five pages are primarily directed to be a backhanded attempt to upset the observations of Gardiner C. Means as to the relative rigidity of prices of manufactured and farm products by rationalizing on the causes of rigid prices in the farm-implement and automobile industry and by describing his tests as "fictitious and misleading." The significant point to Means's discussion which all of his critics overlook lies not in his first chart, the mere exhibition of relative inflexibility in prices, nor in his second chart, which exhibits the correlation between inflexibility and gross magnitude of price change, but in his practical suggestions. An engineer could hardly hope to operate a boiler if he were allowed to control merely one of its elements, say, either the fire, or the water, or the safety valve. The more of these he controls, the more satisfactory will be the results of his operation, because he would blend and compromise every one of the elements to meet the requirements of each of the others, just the same as Means suggests blending one of the elements of price making in our economic system with every one of the others. The critics of Means are merely attempting to divert attention from his practical suggestions for improvement in the economic system by directing attention to some of the minor details.

Adam Smith rendered the economic philosophy that if supply were low, price would be high. Manufacturers today operate under the correct assumption that if supply can be restricted, prices can be maintained. They also operate under the orthodox illusion that high price and high profits are synonymous. They are forced to do this because of the unstable nature and the lack of permanence of the personal income of each individual manager. Let us examine the nature of management control and stockholder ownership in terms of the average situation. Stockholder ownership is composed of numerous small investors and a few large investors. The intention of the average small investor is to place his savings where they will be practically as secure in the long run as in the bank and yet yield a higher return. The purpose of the few large investors is to place the funds which have been entrusted to them and which the wheels of fortune have thrown their way so that they will both yield them a quick and large appreciation and in case of erroneous guessing on their part as to the direction of the stock price, will yield some sort of compensation in the form of dividends. In the first case, where the stock is in the hands of numerous small investors, the prime consideration is dividends, and in the second case, when the stock prices are declining, dividends also become a prime consideration.

Now, management is divorced from ownership. Average management owns a surprisingly small percentage of stock, much less than is necessary for control, and consequently must rely on the current good will of the stockholder for the maintenance of its position. In order to assure itself of this support, expedients which furnish immediate cash become of more importance than the type of fundamentally sound operation which furnishes long-term efficiency, stability, and reliability. Management today is not concerned about the *ultimate* value of the common stock. It becomes the prime function of management in answer to the first instinct of human nature to make it its business to preserve its salary by supplying dividends regularly to the ownership, regardless of the ultimate cost to the particular corporation.

So long as this condition persists, we are destined to continue to have management excesses, cycles, booms, depressions, peace eras, and wars. Until the effects of this situation are rectified or controlled, and until the illusion of price and profit correlation is removed, there is not much purpose in industry looking elsewhere for the cause of its troubles.

Since it is a popular misconception in financial circles that price and profit are synonymous, management which is largely controlled from these circles is forced to play along with this illusion. The farmer is the unfortunate victim of this economic horseplay. He must sell to the manufacturer at the manufacturer's price. The manufacturer converts the farm products into finished goods and through his storage facilities and trade organizations is able to sell them at rigidly fixed prices.

The high light of the book is the quotation from Arthur Jerome Eddy, "In his social relations man has made vast strides in advance of the bold biological proposition, progress is a survival of the fittest. In his commercial and industrial relations he is in that savage condition wherein the destruction of the weak and helpless is carried out not only voluntarily and deliberately and with Spartan firmness, but with precisely the satisfaction a Roman audience watched one gladiator slay another, or a wild beast devour a Christian. Strange how these crude propositions drawn from natural development persist in the field of economics long after they have disappeared from the field of ethics"—"The human law should be not the survival of the strong, but *the survival of all*."

Chapters 1 and 2 are commendable studies on the correlation between price and profits. If Brookings Institution

would confine its activities and the Maurice and Laura Falk Foundation would restrict its support to this type of objective research we could find nothing but praise in our vocabulary for them. It is regrettable that the opinions of Brookings Institution should be allowed to masquerade behind two such chapters as these in the guise of the expression of scientific results. This is merely one small example of the widespread prostitution of the scientific atmosphere (or the deliberate misuse of the word scientific) as a medium for the expression of personal or group opinion.

The title of chapter 11 "Dynamic Price Making," led us to expect great things in the way of some interesting development and exhibition of dynamic economic models. Consequently our disillusionment with the book was complete when we discovered that the authors had merely borrowed this term from the econometrician to cloak some more of their ideas in the dignity and authority attached to scientific effort. Nevertheless we must add that some of the principles discussed in this chapter are highly commendable and we were surprised if not amused to discover that, after turning on Means in their early chapters, the authors had borrowed heavily from him in composing their final chapter. As a matter of fact the engineer will find the reading of the introductory and first four divisions of chapter 11 well worth his reading time.

There is an excellent discussion in Appendix A describing, after the accustomed business manner, how and why price data cannot be used, in case that is of practical importance to the reader. My experience with engineers leads me to believe that they would be more interested in knowing how it can be used. In fact it has been the engineer's record that he has consistently gone ahead and blissfully, but successfully, done many of the things which "couldn't be done." It is our expectation that he will continue to do this, not only in what is now considered the field of engineering, but also in economics, not to mention pricing matters.

In closing, the strictly orthodox Nourse and Drury find only the conventional problem of "weeding out abuses through which the unscrupulous concerns seek to gain an advantage by 'sweating' labor, 'gypping' the consumer on quality, or 'chiseling' his competitor through unfair trade practices," as worth considering. "There is an educational and disciplinary rôle which self-government by the trade group supplemented by government agencies can perform." They "do believe that the trade organization with its intimate technical knowledge of actual operating conditions and problems and the government agency with professional staffs trained to the broader economic repercussions constitute the proper focal point of attack."

"The truly progressive innovating individual must be left free to follow such a course as will enable him to make his contribution to consumer welfare. If either the trade or government agency defines as unfair and seeks to outlaw that competition which the most efficient and daring give the most inefficient or timid, then the solidarity of the group will be used for the preservation of mediocrity. If this occurs, our boasted technology has little chance to make its contribution to the welfare of the mass of consumers."

The book attempts to make a contribution to an understanding of the relationship of price to the function of our economy without taking into account all of the factors that are involved in the situation. No engineer would attempt to report on the operations of a system or even discuss the influence of one element of that system without taking into account the relationship of that element to all the other elements in the system. The book gives all the evidence of a desire to justify the operation of our present economic order. It lacks vitality and is just about as poor an attempt at scientific analysis as has come to the reviewer's notice. It starts nowhere and it leads nowhere.

WALTER RAUTENSTRAUCH.[2]

[2] Professor of Industrial Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

Price-Making

TO THE EDITOR:

In the March issue of MECHANICAL ENGINEERING, R. E. Freeman of the Massachusetts Institute of Technology has reviewed "Industrial Price Policies and Economic Progress." He particularly notes that the authors directed attention to long-term rather than cyclic trends.

One great weakness of studies of this sort is that they ignore the monetary effects which are at the bottom of booms and depressions, pay lip service only to the statement of economists that a depression must continue "until necessary adjustments are made," ignore the factors influencing the size of these adjustments, who make them, and others, and completely disregard the fact that if adjustments must be made after a depression starts, then some adjustments should have been possible all along which might have obviated the need of a depression.

The writer recently published in *Econometrica*, Vol. 7, No. 1, January, 1939, an article entitled "Controlling the Nation's Business" which laid the theoretical foundation of business control for making the adjustments and avoiding the monetary depressions without business curtailment. The nature of purchasing power is adequately discussed and sheds much light on the limitations of the Brookings Institution investigation. This article and the references should be fully grasped before any attempt is made to draw conclusions on this subject. It will also serve to evaluate such proposals as those of Dennison, Filene, Flanders, and Leeds in "Toward Full Employment." Increased government employment after a depression starts is a distinctly artificial means for maintaining full production and is substantially incapable of effecting the necessary adjustments.

Many other subjects, such as business reserves, their nature, the amount required, their use, whether they are fit subjects for income taxing, and so on, may be developed from the methods laid down. Improved accounting methods are basic requirements.

EDWARD ADAMS RICHARDSON.[3]

The Cost of Apprenticeship

TO THE EDITOR:

First of all I want to congratulate Mr. Seely on the frankness with which he has stated some of the details of apprenticeship in his company.[4] I agree with him, that in no well-operated system should there be any doubt that the apprentice, although well paid, fully earns his way. In my company we have something like two hundred apprentices under normal conditions learning five different trades, namely, machine shop, wood patternmaking and metal patternmaking, foundry, coremaking, and drafting. We have had such a system over one hundred years. In fact Lucian Sharpe was an apprentice from 1848 to 1853 to Joseph R. Brown, the founder of our business, so that I can cite Mr. Sharpe as one of our authenticated and oldest apprentices.

We consider our apprentice system of vital import in the production of our machinery and graduates are to be found in every department of our work, from subforemen to sales managers, department

[3] Associated with Bethlehem Steel Company, Bethlehem, Pa. Jun. A.S.M.E.

[4] "The Cost of Apprenticeship," by Warner Seely, MECHANICAL ENGINEERING, December, 1938, pp. 901–903.

managers, and superintendents. In addition we have furnished men as heads of many other businesses. Therefore, I would say that in the long run and in the aggregate of considerations our apprenticeship system is a profitable one.

We prefer that boys shall have had a high-school training and, except in special cases, not be over seventeen years of age. They are in charge of a superintendent of apprentices who sees to it that they are properly instructed, that they do not stay too long on any class of work, and who in general acts as their adviser, both as to their present and future. One-half day each week is spent in the schoolroom at the shop studying mechanical subjects like gearing, reading of drawings, studying limits, the applications of plain geometry and trigonometry to shop problems, and the like. There are dormitories where the boys can secure rooms. They are organized for legitimate amusements like baseball and other athletic games. We have physicians to whom they can be referred for matters pertaining to their health. If they desire to add to their scholastic training arrangements can be made at the Rhode Island School of Design for evening classes.

In addition to the regular four-year apprenticeship courses there are special two-year courses for college graduates. The length of time, however, for such men is adjusted to the needs of the individual. Also we have special two-year courses for training automatic-screw-machine operators, grinding-machine operators, and milling-machine operators. These courses are confined strictly to the subject matter of the titles.

Elmer H. Neff.[5]

To the Editor:

The excellent paper by Mr. Seely ought to impress management for two reasons:

First: Because an effective apprentice training can be practically self-supporting and

Second: Because it provides a reservoir of skilled men who are potential candidates for promotion to supervisory and executive positions.

The statement made by Mr. Seely, "we found that graduates of our regular four-year training program have filled every major production post in this entire company" ought to jar some of those who have never carefully considered a well-planned apprentice-training program.

It might be remarked that the A.S.M.E. Committee on Education and Training for the Industries has had engineering professors, deans, and one president as its chairmen during the last twenty years. I do not recall that industrial executives have been especially active in proclaiming the value of a good apprentice program. On the other hand, those in industry who have been responsible for such industrial education have been willing and effective supporters of it.

R. L. Sackett.[6]

Hard-Surfacing Processes and Materials

To the Editor:

This paper[7] is a good brief discussion of the various methods and uses of surface hardening. The author has given, in concise form, a good picture of the processes for hard surfacing which are available to the engineer at the present time, with some evaluation of the merits of each type.

The statement is made that "hardness is probably the best criterion of wear resistance." The writer can hardly subscribe to this statement as a generalization. It may be said that for a given material higher hardness will generally indicate greater resistance to wear; but in comparing various materials, hardness will not indicate that those materials of higher hardness will be more wear-resistant than those materials of lower hardness. This fact has been borne out by many investigations.

Flame hardening is a process which is being developed with great rapidity. Much work is yet to be done in this field, and great care should be exercised in its use. It should always be remembered that this is a localized heating-and-cooling process, which by its inherent nature sets up localized stresses that in certain cases may be of detrimental character. In many applications this need not detract from the use of this process, and for symmetrical sections great advantages and economies may be derived from its use.

Electroplating of metals has been in use for some time as a means of producing a wear-resistant surface. It should be remembered that electroplating is a complex process and that great care must be taken in the processing treatment, otherwise, erratic results may be obtained. This is particularly true of chromium plating.

The author refers to the hardness of plated chromium as varying from 500 to 900 on the Brinell scale. The writer objects strenuously to the use of Brinell values to designate the hardness of thin-plated surfaces. In the determination of the hardness of such thin coatings one must be careful that the hardness of the backing material does not influence the reading. Such a factor cannot help but come into play when penetration methods are employed. The Rockwell superficial and Vickers tests, however, come the nearest to eliminating this difficulty. The Bierbaum scratch-hardness test has been used as a method of comparing hard materials.

The author has failed to mention one method of surface hardening which would come within the scope of his paper, that is, the method developed by the Industrial Research Laboratories of Los Angeles. A metal developed by this company under the name of "Xaloy,"[8] and which is applied to the surface by means of a centrifugal action, has been used successfully for slush pumps and the like.

In general, the author is to be complimented upon his interesting exposition of the subjects covered.

Donald S. Clark.[9]

To the Editor:

This paper deals with an immense variety of surface treatment and the subject is so vast that there is obvious need of further correlated abstracts.

The induction-hardening and flame-hardening processes are both developing rapidly, although it is not apparent as to why there is not more trouble with cracking of the hard surface during cooling. In both cases the process violates every rule of good heat-treating. It is perhaps fortunate that the magnaflux test is frequently used in both cases to prevent the occasional part which does crack from being put in service and giving a bad impression of an otherwise excellent method of surface preparation.

A. V. de Forest.[10]

To the Editor:

In this interesting paper, the author makes the statement that the nitriding temperature range that is generally used is from 900 to 950 F. This is not correct

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[6] Dean Emeritus of Engineering, The Pennsylvania State College. Mem. A.S.M.E.

[7] "Hard-Surfacing Processes and Materials," by M. L. Begeman, Mechanical Engineering, December, 1938, pp. 931–935.

[8] "Nickel-Boron Cast Iron for Resistance to Abrasions," by Walter Hirsch, *Metal Progress*, September, 1938, pp. 230–232.

[9] Assistant Professor of Mechanical Engineering, California Institute of Technology, Pasadena, Calif. Mem. A.S.M.E.

[10] Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.

for American practice as the range in this country is from 950 to 1000 F, 975 F being most commonly used.

In giving the hardness in terms of Brinell values, the hardness-testing machine that was used should be mentioned. In giving the hardness range of the nitride case as from 900 to 1100 Brinell, the fact that it was obtained with a Vickers machine and that a 10-kg load was used should be stated. Under the heading "Chapmanizing" the author states that the hardness obtained by this method ranges from 700 to 1100 monotron Brinell. A steel case-hardened to 700 monotron Brinell is file-soft. Also, I challenge the statement that the hardness obtained by this method is about the same as that obtained by nitriding.

It is apparent from the discussion of other methods that the term nitriding is used rather loosely. The term was suggested by me a number of years ago to represent the nitrogen hardening process disclosed by Dr. Fry. Before this term was proposed and accepted, the process was referred to under various designations, such as nitrogenizing and nitrodizing. The Fry process is now known throughout the world as nitriding. No further heat-treatment of the parts after exposing them to ammonia gas at from 950 to 1000 F is required by the Fry process.

Processes for introducing nitrogen and carbon into steel at such high temperatures as to necessitate quenching to produce a hard case have been erroneously termed nitriding. In nitriding, the hardness is produced by the precipitation of nitride particles whereas in the quenching processes the hardness is due to the formation of martensite on quenching. I have never found any materials when case-hardened by a process involving a quench that showed a hardness equal to that obtained by nitriding.

Since nitriding requires no further treatment after exposure to the ammonia gas, the amount of distortion that takes place will be less than that shown by any other case-hardening method.

V. O. HOMERBERG.[11]

TO THE EDITOR:

Professor Begeman is to be commended for this excellent summary of hard-surfacing processes and materials. In any such summary it is difficult to place adequate emphasis on one or another of the various alloys and processes, and the author's work might be augmented by a

TABLE 1 ROCKWELL HARDNESS OF DEPOSITS ON MILD STEEL

Type of deposit	Electrode application	Single layer: As deposited	Single layer: Work hardened	Multiple layer: As deposited	Multiple layer: Work hardened	Resistance to corrosion	Heat-treatment
High-carbon steel	Dense tough surface of moderate hardness to resist shock and abrasion	30 C	35 C	35 C	40 C	Poor	Same as for straight carbon steel
Medium-carbon alloy steel	Resist wear due to rolling or sliding friction under high pressures	40 C	43 C	50 C	50 C	Fair	Air hardening
High-speed steel	Cutting edges, metallic friction	58 C	58 C	62 C	62 C	Fair	Like high-speed steel
Semiaustenitic high-carbon alloy steel	Resist impact and severe abrasion	45 C	60 C	27 C	55 C	Good	No heat-treatment. Self-hardening on cold working
High-Mn-Ni-Mo steel	Resist severe impact and abrasion	93 B[a]	50 C[a]	93 B	50 C	Fair	Like high-Mn steel
tainless steel	Resist corrosion, severe impact, and abrasion	35 C	48 C	85 B	42 C	Excellent	Like stainless steel

[a] On manganese steel.

Remarks: Values given are average obtained under laboratory conditions. Results will depend on such variables as current, mass of parent metal, size of bead, rate of cooling, and the like. In most cases no heat-treatment is necessary or desirable. Notes on heat-treatment are only to identify the type of deposit and provide a guide in case of an unusual application where some heat-treatment is used. It should be understood that these hardness values are with no heat-treatments.

slight expansion in his treatment of the nonferrous group. To the elements tungsten, chromium, cobalt, and molybdenum mentioned in this connection carbon should be added, and a specific alloy of tungsten, chromium, cobalt, and carbon, commonly known as stellite, deserves special mention. This material and others in this category derive their wear resistance not only from their retention of hardness at red heat but likewise from a degree of toughness not found in the class of materials listed under the hard metal diamond substitutes. Because of this degree of toughness chipping does not occur under many impact abrading conditions and this obviously results in longer service life. There is one other factor in wear resistance which should be emphasized, namely, corrosion resistance. Wear frequently consists of a combination of corrosion and erosion of the products of corrosion. The corrosion resistance of the chrome-cobalt-base alloys is such that the corrosion-erosion factor is reduced to a minimum. Thus, while hardness plays a most important role in the wear resistance of these alloys, ductility and corrosion resistance are important factors in their service life.

In the nonferrous group no mention is made of brasses or bronzes, and while it may be argued that these are not hard-facing in one sense of the word, it is true that the object of their surface application is to increase wear resistance. Brasses containing small amounts of silicon and of tin are widely used in the form of weld-deposited material for applications involving sliding friction, and lead-bearing bronzes likewise deposited from welding rod find application where rolling friction predominates.

These remarks are intended to supplement Professor Begeman's summary and are given with the thought that they will add to the completeness of this otherwise comprehensive digest.

A. B. KINZEL.[12]

TO THE EDITOR:

Professor Begeman has presented a most interesting and valuable paper. I do wish, however, that he had gone into the subject from the general viewpoint of surfacing or overlaying rather than just hard surfacing.

He discusses this rather lightly. For example, the last part of the second paragraph starting "Considering all factors involved....," compared to the end of paragraph three and the beginning of paragraph four, is a bit confusing. In one case, it is said "hardness is probably the best criterion" and in another "hardness does not give a true index as to rapidity of wear."

Under head of Fusion Welding Processes, the third sentence in reference to puddling should be clarified; the arc permits accurate control not excessive puddling. The various surfaces which can be deposited should be described.

It is true that deposit of high-carbon

[11] Associate Professor of Physical Metallurgy, Massachusetts Institute of Technology, and technical director of The Nitralloy Corporation.

[12] Chief Metallurgist, Union Carbide and Carbon Research Laboratories, Inc., New York, N. Y.

steel is done economically, but there are other surface conditions to be met and the comparative hardnesses given should be further explained.

A tabulation such as given in Table 1 (on the previous page) would be helpful.

I cannot subscribe to the statement that oxyacetylene is preferred. It covers too much territory and should be modified.

The bibliography is particularly valuable and the paper as a whole, a contribution to the subject.

E. W. P. SMITH.[13]

TO THE EDITOR:

The author is very appreciative of the criticisms and additions to the paper that have been brought out in these discussions. They further emphasize the need for more fundamental research on hard-facing material. Such problems as the relation between ductility and hardness; adherence of facing metal when subjected to bending or impact; hardness of facing metal as a function of parent-metal thickness, deposit thickness, kind of parent metal, and grain size; and wear resistance of deposits under various loading conditions should be known to facilitate making a proper selection for a given application. Many materials are now available under different trade names, but little has been done to rate them according to their useful properties and possible applications. Until this is done it will continue to be difficult for any prospective user to compare the competing products.

Some comment was made as to the method of hardness testing used for several of the hard-surfacing processes. Obviously for extremely thin coatings the Brinell method should not be used. The hardness numbers obtained from various authorities were converted to either Brinell or Rockwell hardness for purpose of comparison.

One material known as "Xaloy," a nickel iron containing boron with a high carbon and low silicon content, was not mentioned in the paper, but was discussed during the presentation. The outstanding feature of this hard-facing material is that it may be applied as liners to tubes by centrifugal casting. The hardness obtained according to the Rockwell C scale is 68–70. This hardness is inherent and does not depend upon any subsequent heat-treatment or chilling.

M. L. BEGEMAN.[14]

[13] Consulting Engineer, The Lincoln Electric Company, Cleveland, Ohio.

[14] Associate Professor of Mechanical Engineering, University of Texas, Austin, Texas.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of February 17, 1939, which were subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 859

(Annulled)

CASE No. 861 (Reopened)

(Special Ruling)

Inquiry: Case No. 834 covers Par. U-68 unfired pressure vessels of stabilized chrome-nickel steel conforming to A.S.T.M. Specifications A 167-35T, grade 4. Will it be permissible to apply the code symbol stamp to unfired pressure vessels fabricated to Par. U-69 omitting the heat-treatment and special tests required in the reply to Case No. 834?

Reply: It is the opinion of the Committee that stabilized austenitic chrome-nickel steel conforming to A.S.T.M. Specifications A 167-35T, grade 4, may be used for vessels constructed under Par. U-69 with the following limitations:

(1) The chemical composition and physical properties are modified as follows from A.S.T.M. Specifications A 167-35T, grade 4:

Carbon, max, per cent............0.07
Manganese, per cent..............0.40–2.50
Chromium, min, per cent.........17
Nickel, min, per cent.............9.5
Columbium,[1] min = 10 times carbon content; 1 per cent max
Titanium,[1] min = 6 times carbon content; 0.60 per cent max
Tensile strength, lb per sq in., min.....75,000
Yield point, lb per sq in., min.........35,000
Elongation in 2 in., min, per cent......30

(2) Maximum temperature of 600 F; maximum pressure of 400 lb per sq in.; maximum thickness $^1/_2$ in.; allowable stress 15,000 lb per sq in., with a joint efficiency of 80 per cent.

(3) Austenitic chrome-nickel stainless steels, when in a condition of internal stress and exposed to certain aqueous chloride solutions, or other corrosive environments, may fail by stress corrosion cracking. In order to take advantage of the omission of a stress-relieving and stabilizing heat-treatment as covered by the preceding paragraphs of this reply, consideration should be given to the possibility of stress corrosion in the welds and affected zones.

[1] Either columbium or titanium shall be used.

CASE No. 870

(Special Ruling)

Inquiry: Is it permissible, in the construction of welded boilers of the locomotive type, to insert into an extended shell the smokebox tube sheet, flanged outwardly and welded to the shell by a circumferential fillet weld which can be stress-relieved but cannot be satisfactorily radiographed? The tube sheet will be supported by diagonal braces and tubes in the same manner as in riveted boilers where tube sheets are commonly inserted with the flange outward and single riveted to the shell.

Reply: It is the opinion of the Committee that a tube sheet flanged outwardly may be inserted in the smokebox end of the shell of a locomotive-type boiler and attached thereto by a circumferential fillet weld that is not radiographed, provided:

(1) This joint is wholly within the shell and forms no part thereof;

(2) The shear stresses in the fillet weld used do not exceed that provided for in Par. P-268*h;*

(3) The construction conforms in all other respects with the requirements of the Code including bracing, type of welding, stress relieving, etc.

The broad general requirements of Par.

P-105 were not intended to apply to this type of construction.

CASE No. 873

(Interpretation of Table P-16)

Inquiry: In order to fill an urgent need, may the proposed revision of Table P-16 for safety valve openings on fire-tube boilers as published on page 77 of the January, 1939, issue of MECHANICAL ENGINEERING be made effective immediately?

Reply: Since no changes in the proposed revision of Table P-16 as published are indicated, it may be used in place of the present table pending the issuance of the customary schedule of revisions in the form of the addenda sheets.

CASE No. 874

(Interpretation of Specification S-34)

Inquiry: As manufacturers of tubing advise that it is impossible to make austenitic steel tubes for high temperature use with the maximum manganese limitations in Specifications S-34, grade P-8*b*, when columbium stabilized, and as the increasing of the manganese content improves the corrosion resistance and markedly improves the hot forging and piercing properties of this alloy, will it be considered as meeting the intent of the code if, for columbium stabilized tubes manufactured according to grade P-8*b* of Specification S-34, the maximum content of the manganese be increased from 0.70 to 1.50 per cent with a minimum columbium content of 0.70 per cent? This agrees with the proposed tentative A.S.T.M. specification for boiler and superheater tubes where the manganese content is increased to 1.50 per cent.

Reply: It is the opinion of the Committee that the intent of the Code will be met if, for columbium stabilized tubing under grade P-8*b* of Specification S-34, the maximum manganese content is increased from 0.60 to 1.50 per cent with a minimum columbium content of 0.70 per cent.

CASE No. 875

(Interpretation of Table A-9)

Inquiry: Is it the intent of the Boiler Code Committee to revise Table A-9 to conform with the American Standard for Steel Pipe Flanges and Flanged Fittings (B16e–1939)? If so, is it permissible to use these values until such revisions are adopted?

Reply: It is the intent of the Committee to revise Table A-9 to conform with American Standard B16e–1939 and until such revisions are adopted, it is permissible to follow the adjusted pressure ratings given in this standard.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-17. Revised second sentence:

The minimum thickness of plates to which stays MAY BE [are] applied IN OTHER THAN CYLINDRICAL OUTER SHELL PLATES shall be $^{5}/_{16}$.

PAR. P-23. In the formula omit "*E*" wherever it appears, and omit definition of "*E*;" in definition of "*S*" change table reference to "Table P-6."

PAR. P-103. In (*a*) include reference to Specification S-34; in (*b*) revise first sentence to read:

Material for manhole frames, nozzles, and other pressure connections which are to be joined to the shell, [or] heads, PIPE, OR TUBES by fusion welding, etc.

PAR. P-112. To be replaced by the following:

P-112. *Welded Connections. a* Circumferential joints of pipe or tubes may be fusion-welded within the following limiting conditions and as provided in this paragraph:

(*1*) Pipe or tubes, not exceeding 16 in. nominal pipe size or $1^{5}/_{8}$ in. wall thickness, that are to contain steam, and those not exceeding 10 in. nominal pipe size or $1^{1}/_{8}$ in. wall thickness, that are to contain water, when in each case the welds are not to be in contact with furnace gases;

(*2*) Pipe or tubes, not exceeding 6 in. nominal pipe size or $^{3}/_{4}$ in. wall thickness, when the welds are to be in contact with furnace gases but not subject to radiation from the furnace;

(*3*) Pipe or tubes, not exceeding 4 in. outside diameter or $^{1}/_{2}$ in. wall thickness, when the welds are to be in contact with furnace gases and subject to radiation from the furnace;

(*4*) The diameter and thickness limitations shall apply independently. A weld will not be considered as subject to radiant heat from the furnace when in a portion of a tube that has five or more rows of tubes between it and the furnace.

b The materials used shall comply with the requirements of Par. P-103.

c All circumferential fusion-welded joints in tubes, or pipes, welded in accordance with the provisions of this paragraph, shall have a double-welded butt joint or single-welded butt joints made the equivalent of a double-welded butt joint (See Note in Par. P-101).

The butt weld shall be reinforced at the center of the weld by at least $^{1}/_{16}$ in. The strength of the weld shall be sufficient to develop the full strength of the tube in the longitudinal direction. There shall be no valley or groove along the edge or in the center of the weld, and the deposited metal must be fused smoothly and uniformly into the tube surface at the top of the joint. The finish of the welded joint shall be reasonably smooth and free from irregularities, grooves, or depressions. The design of and the method of welding the joint shall be such that there will be no appreciable projection of weld metal past the inside tube surface.

Backing rings shall be used for all pipe or tube single V-welded joints where the outside diameter exceeds $1^{1}/_{2}$ in. The backing rings shall either be removed after welding or shall be fused integrally with the weld. A backing ring which is to be left in the tube or pipe up to and including $5^{1}/_{2}$ in. in outside diameter shall be limited in inside diameter to $^{3}/_{16}$ in. less than th maximum permissible inside diameter of the tube or pipe, or to a diameter $^{1}/_{16}$ in. less than the minimum permissible inside diameter, whichever is the smaller diameter, shall be not more than $^{3}/_{8}$ in. wide, and shall have such a contour on the projection into the tube or pipe so that there will be a minimum restriction to flow and in the case of tubes to permit the use of tube cleaners past the joint. Some acceptable designs of backing rings and joints where the backing rings are to be left in place after welding are shown in Fig. P-$5^{1}/_{2}$. These dimensions for backing rings are for tubes and pipe up to and including $5^{1}/_{2}$ in. in outside diameter, and, if applicable, may be used for larger sizes.

All pipe or tube joints welded under the provision of this paragraph shall be stress-relieved in accordance with Par. P-108, and shall be hydrostatically tested in accordance with Par. P-329. The hydrostatic and hammer test provided in Par. P-109 will not be required. No radiographic examination of such welded joints will be required.

d The qualification of welding processes and operators for fusion-welded circumferential joints in tube or pipe under the requirements of

Table P-6. To be reinserted in the following form:

TABLE P-6 VALUES OF FACTOR S TO BE USED IN FORMULAS IN PAR. P-23 AND TABLE P-2

Spec. No.	Grade	Min t.s.	Min Silicon	For temperatures not exceeding deg F: 650	700	750	800	850	900	950	1000
SEAMLESS STEEL											
S-17	A	47000	0.10	9400	9000	8600	7900	6800	5600	3800	2000
S-40	A	47000	0.10	9400	9000	8600	7900	6800	5600	3800	2000
S-18	Low Carbon	47000	0.10	9400	9000	8600	7900	6800	5600	3800	2000
S-17	A	47000	..	9400	9000	8100	7150	5850	4400	2600	...
S-18	Low Carbon	47000	..	9400	9000	8100	7150	5850	4400	2600	...
S-49	C	60000	0.10	12000	12000	10400	9100	7400	5600	3800	2000
S-18	Med Carbon	62000	0.10	12000	12000	10400	9100	7400	5600	3800	2000
S-18	Med Carbon	62000	..	12000	11400	9950	8300	6350	4400	2600	...
S-48	T 1	55000	0.10	11000	11000	11000	11000	10500	10000	8000	5000
S-45	P 1	55000	0.10	11000	11000	11000	11000	10500	10000	8000	5000
S-48	T 1a	60000	0.10	12000	12000	12000	12000	11000	10000	8000	5000
S-17	B	40000	..	8000	7650	6900	...	...	...	...	...
ELECTRIC-RESISTANCE WELDED											
S-32	A	47000	0.10	8000	7650	7300	6700	5800	4750	3250	1700
S-32	A	47000	..	8000	7650	6900	6100	5000	3750	2200	...
S-32	B	40000	..	6800	6500	5850	...	...	...	...	...
S-32	C	60000	0.10	10200	10200	8850	7750	6300	4750	3250	1700
S-32	C	60000	..	10200	9700	8450	7050	5400	3750	2200	...
LAP-WELDED											
S-17	Steel	45000	..	7650	7000	6650	5860	4850	3750	2200	...
S-18	Steel	45000	..	7650	7000	6650	5860	4850	3750	2200	...
S-17	Wrought Iron	40000	..	5600	5300	5100	...	...	...	...	...
S-19	Wrought Iron	40000	..	5600	5300	5100	...	...	...	...	...
BUTT WELDED											
S-18	Steel	45000	..	5400	5100	4700	...	...	...	...	...
S-19	Wrought Iron	40000	..	4800	4600	4400	...	...	...	...	...
FUSION WELDED[a]											
S-1		55000	..	9900	9350	8300	7200	5700	3950	2350	...
S-2	B	50000	..	9000	8550	7650	6750	5400	3950	2350	...
S-2	A	45000	..	8100	7650	7000	6200	5150	3950	2350	...

[a] NOTE: Fusion welded in accordance with Pars. P-101 to P-111, inclusive.

Par. P-112 (continued)

this paragraph shall be in accordance with the qualification procedure in the Appendix, Pars. A-100 to A-120.[1]

The manufacturer shall be responsible for the quality of the welding done by his organization and shall conduct tests not only of the welding process to determine its suitability to insure welds which will meet the required tests, but also of the welding operators to determine their ability to apply the procedure properly. The qualification tests herein specified shall be considered as remaining in effect indefinitely unless the welding operator has not been engaged on welding according to the requirements of this paragraph or Pars. P-101 to P-110 for three months or more, or unless there is some specific reason to question an operator's qualification, in which case he shall be required to requalify. The manufacturer shall keep records of test results of qualification of processes and operators. A sample form is given in Pars. A-100 to A-120.[1] The qualification tests of operators shall be accepted by an authorized inspector upon the results of the tests conducted by the manufacturer and certified by the manufacturer as applying to a given process and by a given operator in accordance with the procedure in Pars. A-100 to A-120.[1] It is not necessary for the inspector to witness the welding of the test welds or the tests of such welds.

When welding in accordance with the requirements of this paragraph is done in the field away from the manufacturer's shop, at least one of the welding operators shall have been regularly employed upon production work under the requirements of this paragraph or Pars P-101 to P-110 for a period of one year or longer, or shall be regularly employed by the manufacturer as a supervisor of welding operators or as a technical welding expert.

The tests conducted by one manufacturer shall not qualify a welding operator to do work for any other manufacturer. No production work shall be undertaken by an operator until both the process and the operator have been qualified.

PAR. P-186*b*. Revise to read:

b Fusion welding may be used in boilers IN CASES WHERE THE STRESS OR LOAD IS CARRIED BY OTHER CONSTRUCTION WHICH CONFORMS TO THE REQUIREMENTS OF THE CODE AND WHERE THE SAFETY OF THE STRUCTURE IS NOT DEPENDENT UPON THE STRENGTH OF THE WELD PROVIDED THE MATERIAL IS PERMITTED TO BE WELDED, OR AS OTHERWISE specified in this PARAGRAPH [section of the code].

PARS. P-198 and U-39. Add the following:

$C = 0.30$ for plates held by set bolts in line with the gasket as shown in Fig. P-26*m* (U-2*m*), provided the design of all holding parts against failure by shear, tension, or compression resulting from the end force due to pressure, is based on a factor of safety of at least 5, and threaded joints, if any, are at least as strong as for standard piping of the same diameter.

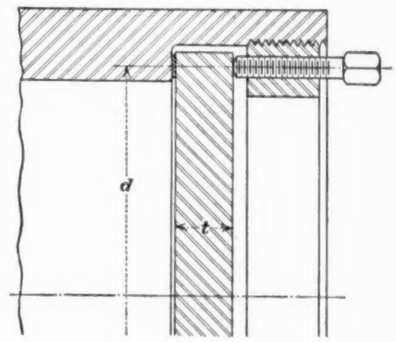


FIG. P-26*m* (U-2*m*)

Table P-16. Revise formula in proposed revision of this table appearing in January, 1939, MECHANICAL ENGINEERING to read:

$$A = \frac{HV}{420}$$

where A = total area of openings, sq in., H = boiler heating surface, sq ft, V = specific volume at maximum allowable working pressure, cu ft per lb.

PAR. P-269*a*. Revise first sentence to read:

Each boiler shall have at least one safety valve and if it has more than 500 sq ft of water heating surface [or the generating capacity exceeds 2500 lb per hr,] it shall have two or more safety valves.

PAR. P-278. Revise second sentence to read:

In the case of fire-tube boilers, the openings in the boilers for safety valves [and the outlet opening or openings of any intervening fittings] shall be not less than that given in Table P-16 [for capacities determined in accordance with Par. P-274].

PAR. P-299. Add a footnote to read:

Where the word "fittings" is used, it is to be understood that pipe fittings are meant and it does not include other types.

PAR. P-299*a*. Add the following:

All valves and fittings shall be marked with the name, trade-mark, or other identification of the manufacturer, and the maximum allowable working pressure. Additional markings as called for in the American Standards are recommended if the size and shape of the valve or fitting permit.

PAR. P-299*a*. Add the following:

PAR. UA-17*g*. Replace by the following:

Rolled or forged flanges may be in accordance with the requirements of Specification S-8 or S-50 (A.S.T.M. A 181) for 100 and 300-lb standard fittings or connections and shall be in accordance with the requirements of Specification S-8 for 400 lb and higher pressure standards.

PAR. P-299*c*. Add the following:

Valves and fittings made of any material

[1] These paragraphs consist of a Standard Qualification Procedure for Manual Gas and Arc Welding Butt Joints in Pipe or Tubes. They are not included here due to lack of space, but copies may be obtained upon application to the Secretary of the Boiler Code Committee, A.S.M.E., 29 W. 39th St., New York, N. Y.

permitted by the Code for pressure ratings of 125 lb or more, and marked as required by the Code, may be used for saturated steam service up to the rated pressure except that in no case shall they be used for temperatures exceeding that permitted by Tables P-8 and P-9, and Par. P-12.

PAR. P-299*d*. Revise second section to read:

VALVES AND FITTINGS MADE OF ANY MATERIAL PERMITTED BY THE CODE FOR PRESSURE RATINGS OF 125 LB OR MORE AND MARKED AS REQUIRED BY THE CODE MAY BE USED FOR FEED LINE AND BLOW-OFF SERVICE UP TO 80 PER CENT OF THE RATED PRESSURE, EXCEPT WHERE CERTAIN MATERIALS ARE SPECIFIED, AND THAT IN NO CASE SHALL THEY BE USED FOR TEMPERATURES EXCEEDING THAT PERMITTED BY TABLES P-8 AND P-9, AND PAR. P-12. [Cast-iron valves of intermediate standards between 125 and 250 lb pressure which have their pressure ratings plainly marked on the valves may be used for this service up to 80 per cent of their rated value.]

PAR. P-299*e*. Revise second section to read:

Valves and fittings of steel construction equal to the American Standards given in Table A-6 may be used FOR MAXIMUM SATURATED STEAM PRESSURE AND for feed and blow-off services for maximum allowable boiler pressures which have been adjusted as follows:

permitted by Tables P-8 and P-9, and Par. P-12.

TABLE A-5. Editorial corrections will be made in the notes to this table to make it conform to latest American standard. Change title to read:

Steel PIPE FLANGES AND Flanged Fittings [and Companion Flanges]. The following table is taken from American Standard B16e–1939 [1932]. Table A-5. Facing Dimensions for the American 100-, 300-, 400-, 600-, 900-, 1500-, and 2500-Lb [Steel] Flanges.

TABLE A-6. Editorial corrections will be made in this table to make it conform to latest American standard, and values will be added for the 2500-lb pressures. Change title to read:

Steel PIPE FLANGES AND Flanged Fittings [and Companion Flanges]. The following table is taken from American Standard B16e–1939 [1932]. Table A-6. Dimensions of Flanges for Maximum Steam Service Pressure at a Temperature of 750 F.

TABLE A-7. Omit all dimensions over 5 in. sizes. Change title to read:

Cast-Iron FLANGES AND Flanged Fittings. Table A-7. Dimensions of 125-lb Cast-Iron Flanges. The following table is taken from American Standard B16a–1939 [1928].

MAXIMUM BOILER PRESSURES FOR USE OF AMERICAN STANDARD STEEL PIPE FLANGES AND FITTINGS

ADJUSTED PRESSURE RATINGS FOR CARBON STEEL FLANGES AND FLANGED FITTINGS WITH RATINGS AT 750 F

Type of Joint	100	300	400	600	900	1500	2500
	Maximum allowable saturated steam pressure						
Standard facings	180	400	520	750	1080	1710	2680
Ring joint	190	430	550	790	1130	1760	2730
	Maximum allowable boiler pressure for feed line and blow-off line under this paragraph and Par. P-310						
Standard facings	150	320	420	610	900	1400	2200
Ring joint	160	350	450	650	930	1460	2260

ADJUSTED PRESSURE RATINGS FOR CARBON MOLYBDENUM STEEL FLANGES AND FLANGED FITTINGS WITH RATINGS AT 900 F

Type of joint	100	300	400	600	900	1500	2500
	Maximum allowable saturated steam pressure						
Standard facings	...	480	610	900	1290	2030	3150
Ring joint	...	540	700	1010	1440	2240	3520
	Maximum allowable boiler pressure for feed line and blow off line under this paragraph and Par. P-310						
Standard facings	...	390	500	730	1060	1670	2600
Ring joint	...	440	570	830	1180	1850	2870

PAR. P-299*j*. Revise to read:

j Bronze valves and fittings made of material complying with Specification S-46 shall be limited to temperatures of 406 F. If made of material complying with Specification S-41, the maximum allowable temperature is 550 F. Allowable working stresses are not to exceed the values given in Table P-8, except as provided for in Par. P-269*b*.

PAR. P-302. Replace the third section by the following:

Valves and fittings made of any material permitted by the Code for pressure ratings of 125 lb or more and marked as required by the Code, may be used for saturated steam service up to the rated pressure, except that in no case shall they be used for temperatures exceeding that

TABLE A-9. To be revised to conform with Tables 6, 8, 10, and 11 of American Standard B16e–1939.

TABLE A-12. This will be a new table for ring joint flanges and will incorporate Tables 18, 24, 30, 36, 42, 48, 54, and 55 of American Standard B16e–1939.

PARS. H-64 and H-117. Add the following as (*c*):

c Any or all of the fittings and appliances required by these rules may be installed inside of boiler jackets provided that the water gage and try-cocks on a steam boiler must be accessible without the use of tools and provided that the water gage and pressure gage on a steam boiler or the thermometer and pressure gage on a water boiler are visible through an opening or openings at all times.

PAR. U-13*c*. Revise first sentence to read:

Steel plates for any part of a pressure vessel which is to be constructed with other than riveted joints shall be of the quality specified for the particular kind of joint used, except that when steel conforming to Specification S-26 [S-28 grade A, S-43, or S-44] is employed for the construction of UNSTRESS RELIEVED vessels under the requirements of Par. U-69; etc.

Add the following:

These requirements do not apply when the vessel is to be stress relieved, except that in any case the requirements of Par. U-76*b* shall be met.

Vessels made under the requirements of Pars. U-69 or U-70 from material conforming to Specifications S-28 grade A, S-43, or S-44, shall be stress relieved for all thicknesses.

PAR. U-20*f*. Revise to read:

f All valves and fittings shall be marked with the name, trade-mark, or other identification of the manufacturer, and the maximum allowable working pressure. Additional markings as called for in the American standards are recommended if the size and shape of the valve or fittings permit. Bronze valves and fittings made of material complying with Specification S-46 shall be limited to temperatures of 406 F. If made of material complying with Specification S-41, the maximum allowable temperature is 550 F. Allowable working stresses are not to exceed the values given in Table U-4.

PAR. U-76*b*. Revise to read:

b UNLESS OTHERWISE LIMITED BY THE PROVISIONS OF PAR. U-13*c* vessels constructed in accordance with Par. U-69 shall be stress relieved where the thickness exceeds $1^1/_4$ in., or where both the wall thickness is greater than 0.58 in. and the shell diameter less than 20 in., and for other wall thicknesses and shell diameters where the diameter in inches is less than $120t - 50$, where t is the thickness in inches.

PAR. U-78. Add the following as (*g*):

g In the case of vessels built in accordance with Par. U-69 or U-70 the plate thickness of which is over $^1/_4$ in., one or more specimens shall be removed from the welded joints for examination for soundness. The specimens shall be such as to provide a full cross section of the welded joint and may be removed by trepanning a round plug or by any equivalent method. For lap joints specimens need be taken from the outer edge only. At least one specimen shall be taken from each vessel except that when there are a number of similar vessels, each having less than a total of 50 ft of welded longitudinal and circumferential joints, built at the same time and under the same specifications, a specimen for each 50 ft or fraction thereof will suffice; from a vessel having more than 50 ft of welded joints two specimens shall be taken; and from a vessel having more than 100 ft of welded joints, three specimens shall be taken. If more than one method of welding is used or if more than one operator does the welding, at least one specimen shall be taken for each method and for each operator.

The authorized inspector shall designate the points from which the specimens are to be taken.

Cylindrical specimens or those not having a plane surface shall be sectioned across the welds to obtain plane surfaces which shall include the full width of the weld. The plane surfaces shall be polished to a bright, smooth condition which may be accomplished by filing or grinding and polishing with emery cloth and should be completed with the use of emery cloth of grade 00. The specimen shall then be etched by any method or solution which will reveal the defects without unduly exaggerating or enlarging them (See Appendix, Par. UA-47).

As respects soundness, defects are defined as gas pockets, slag inclusion, lack of fusion and cracks. Defects in specimens other than cracks, in the weld metal, shall be permissible when:

(1) There is a lack of fusion or slag inclusion between layers, substantially parallel with the plate surface and which is not more than one-half the width of the weld metal.

(2) When there is a lack of fusion or slag inclusion across the thickness of the plate not more than 10 per cent of the thickness of the thinner plate.

(3) There are gas pockets that do not exceed $^1/_{16}$ in. in greatest dimension and when there are no more than six gas pockets of this maximum size per square inch of the weld metal or where the combined areas of a greater number of pockets do not exceed 0.02 sq in. per sq in. of weld metal.

When a specimen shows nonpermissible defects, two additional specimens may be cut from the same operator's work, at intervals to be determined by the inspector, on each side of the defective specimen. If the additional specimens are found to be not acceptable then more may be cut at intervals to be determined by the inspector until the limit of the defective welding has been definitely established; or the manufacturer may X-ray adjacent joint lengths; or he may cut out and replace all the welding done by that operator without cutting out additional samples.

If more than one of the additional specimens or the X-ray film shows objectionable defects the vessels shall be rejected or the welds may be chipped or melted out from one or both sides of the joint as required and be rewelded. The removal of only that portion of the joint shown to be defective need be required. All replacement welds in joints shall be checked by repeating the original test procedure.

Holes in plates formed by trepanning plug specimens shall be filled by the insertion and welding in of special filler plugs designed in

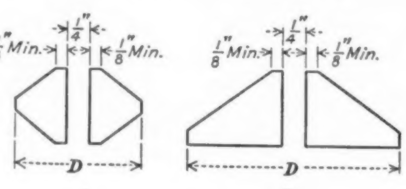


FIG. U-14$^1/_2$

accordance with Fig. U-14$^1/_2$. Design *A* is adapted to welding from both sides and shall be used wherever that method is practicable. Design *B* shall be used when access is possible only from one side. The diameter of the filler plug shall be such as to make a snug fit in the hole to be filled. Each layer of weld metal as deposited shall be thoroughly peened to reduce residual stresses. The $^1/_4$ in. hole in the center of the plug, shown in the figure, shall be closed by threading the opening and inserting a pipe plug which may be seal welded if desired.

Where gas welding is employed, the area surrounding the plugs shall be preheated prior to its welding.

If specimens are removed by other than the trepanning process the openings shall be closed as directed by the inspector.

Local radiographic examination may be substituted for the removal of specimens. Radiographs shall be judged by Par. U-68. The inspector shall designate the places to be radiographed.

PAR. UA-47 will describe several suitable etching solutions.

PAR. U-91. Revise last two sentences to read:

THE MATERIAL USED IN THE FABRICATION OF BRAZED VESSELS SHALL CONFORM TO ANY OF THE SPECIFICATIONS MENTIONED IN PAR. U-71. [Plates $^1/_4$ in. in thickness or heavier shall be of either flange or firebox quality as provided for in Specification S-1 for Steel Boiler Plate. Sheets lighter than $^1/_4$ in. shall have the properties as provided for in Specification S-3 for Steel Plate for Brazing.]

SPECIFICATION S-4. Insert the following as Par. 1.

1. Scope. These specifications cover three grades of carbon-steel hollow-forged drums corresponding to firebox quality for use in boilers and for other pressure vessels. Grades 1 and 2 are suitable for fusion welding. Grade 3 is not to be used when it will in any way be subjected to fusion welding. The term grade is used to distinguish between different tensile limits.

PAR. 9. Revise to read:

9. Bend Tests. The test specimen shall stand being bent cold through 180 deg, without cracking on the outside of the bent portion, as follows: For Grade 1 material, around a pin 1 in. in diameter; for Grade 2 material, around a pin $1^1/_4$ in. in diameter; and for Grade 3 around a pin $1^1/_2$ in. in diameter.

PAR. 4. Revise to read:

4. Chemical Composition. The steel shall conform to the following requirements as to chemical composition:

	Grade 1	Grade 2	Grade 3
Carbon, max, per cent	0.35	0.35	0.50
Manganese, per cent	0.40–0.90	0.40–0.90	0.50–0.90
Phosphorus, max, per cent, acid	0.04	0.04	0.05
Phosphorus, max, per cent, basic	0.035	0.035	0.035
Sulphur, max, per cent	0.04	0.04	0.04
Silicon, per cent	0.15–0.30	0.15–0.30	0.30 max

SPECIFICATION S-3. To be dropped.

SPECIFICATION S-8. To make this specification identical with A.S.T.M. A 105-38, a new Par. 5 will be inserted, and Pars. 6*b*, 10*d* will be revised.

SPECIFICATION S-9. To make this specification identical with A.S.T.M. A 96-38, revisions will be made in Pars. 1*d*, 16, 17, Table 1.

SPECIFICATION S-19. To make this specification identical with A.S.T.M. A 72-38, revisions will be made in Par. 3 and Table 1.

SPECIFICATION S-33. To make this specification identical with A.S.T.M. A 157-38, revisions will be made in Pars. 5, 8*a*.

SPECIFICATION S-34. To make this specification identical with A.S.T.M. A 158-38, revision will be made in Par. 11.

SPECIFICATION S-35. To make this specification identical with A.S.T.M. A 182-38, revisions will be made in Pars. 7*c*, 8, 11*a*.

SPECIFICATION S-38. To make this specification identical with B 25-38T, revisions will be made in Pars. 2, 3, 5, 10, 12.

SPECIFICATION S-39. To make this specification identical with A.S.T.M. Specifications B 79-38T, revisions will be made in Pars. 2, 3, 5, 6, 10, 12.

SPECIFICATION S-45. To make this specification identical with A.S.T.M. Specifications A 206-38, revisions will be made in Par. 5.

SPECIFICATION S-47. To make this specification identical with A.S.T.M. Specifications B 111-37T, revisions will be made in Pars. 3, 4, 6, 7.

SPECIFICATION S-50. This will be a new specification which will be identical with A.S.T.M. Specifications A 181-37 with the addition of a footnote reading:

When the carbon limit of 0.35 per cent, given in Par. 6*b*, is to apply for flanges to be welded, the steel shall contain 0.15 to 0.30 per cent silicon, and the maximum limit for manganese may be 0.90 per cent.

SPECIFICATION S-51. This will be a new specification which will be identical with A.S.T.M. Specifications A194-38T.

PAR. 8. Revise to read:

8. Tension Tests. The forging shall conform to the following requirements as to tensile properties:

	Grade 1	Grade 2	Grade 3
Tensile strength, min, lb per sq in	60,000	70,000	75,000
Yield point, min, lb per sq in	0.5 tens. str.	0.5 tens. str.	0.5 tens. str.
Elongation in 2 in., min, per cent	26	24	24
Reduction of area, min, per cent	42	38	38

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Internal-Combustion Engine

The Internal-Combustion Engine. By C. Fayette Taylor and Edward S. Taylor, International Textbook Company, Scranton, Pa., 1938. Cloth, 6 × 9 in., ix and 322 pp., 169 figs., 12 tables, bibliography, $3.50.

Reviewed by H. E. Degler[1]

MUCH of the material in this book is based upon experimental data obtained in the automotive laboratories of the Massachusetts Institute of Technology under the personal direction of the authors. Considerable material has been included on the properties of fuels and the chemistry of their combustion. The authors stress the fuel problem as a significant one, this approach is commendable in view of the present trend toward increasing engine rotative speeds; the effect of the shape of the combustion-chamber and methods of supplying the fuel to the cylinder, which are of much importance in connection with the combustion process, have also been emphasized. The theories concerning detonation, and the effects of combustion-chamber design and of engine operating conditions on detonation have been well presented with the aid of interesting graphs based on experimental work.

The authors are to be commended for their use of the terms *spark-ignition* engine instead of Otto-cycle engine, *compression-ignition* engine instead of Diesel engine, *two stroke* instead of two cycle and *four stroke* instead of four cycle; undoubtedly the adoption by an increasing number of authorities of the terms italicized will probably lead to a more general recognition of these names by the press and public in the course of time. No pages in this book are wasted by delving into historical matter; the treatment has been made as brief as practicable with no descriptions of specific engines and very little on the design of engine parts.

The theory of the internal-combustion engine is concisely presented, but no numerical examples, applying the theory, have been included; the omission of problems would probably preclude its use as a textbook by many teachers. Over 500 well-selected references to recently published articles and books on the various correlated phases of internal-combustion-engine theory, analysis, and performance are appended as a bibliography. Although this book includes only 292 pages of text material, it contains much basic information which should be of value to the student, the designer, and the research engineer on the internal-combustion engine, one of the most fascinating and rapidly advancing branches of engineering.

[1] Professor of Mechanical Engineering, chairman of the department, The University of Texas, Austin, Texas. Mem. A.S.M.E.

Books Received in Library

Aerodromes, Their Location, Operation, and Design. (Air Transport Series.) Sir Isaac Pitman, London; Pitman Publishing Corporation, New York; 1938. Cloth, 6 × 9 in., 120 pp., illus., diagrams, charts, tables, $4.20. This book contains an account of researches made by the Scientific Institute for Air Transport of the Stuttgart Technical College, into the technical and economic problems involved in the location, operation, and design of airports. The researches discuss not only the airport as a technical and operating unit, but also its importance in the scheme of airways.

Atlas Metallographicus. Band II, Lieferung 5, Tafel 33–40, Abbildungen 230–293. BAND II, Lieferung 6, Tafel 41–48, Abbildungen 294–352. By Hanemann and Schrader. Gebrüder Borntraeger, Berlin, 1939. Paper, 8 × 11 in., illus., diagrams, charts, tables, 18.25 rm. These two new installments of this useful collection of photomicrographs of metal structures add 123 new examples to the collection. These refer to gray cast iron and exhibit the structure of various types, cast for numerous purposes and in manifold ways. Each photograph is accompanied by a description of the article photographed and an analysis of the structure.

Depreciation, Principles and Applications. By E. A. Saliers. Third edition. Ronald Press Co., New York, 1939. Cloth, 6 × 9 in., 482 pp., charts, tables, $5. A summary and interpretation of approved present-day practice, this book considers all the aspects of business-management, operating finance, and accounting in their connection with depreciation and valuation, including actual methods of procedure. Problems are analyzed and the practical and legal aspects of various methods of treatment are discussed. Full tables of probable useful life and depreciation rates for hundreds of items are appended.

Deutsches Museum Abhandlungen und Berichte, Jg. 10, Heft 6. Neue Wege der Flugtechnik, by H. Focke. V.D.I. Verlag, Berlin, 1938. Paper, 6 × 8 in., 166 pp., illus., tables. 0.90 rm. This lecture, by the distinguished German airplane builder, describes the development of three modern types of planes; the tailless, the helicopter, and the canard.

Engineers' Manual. By R. G. Hudson. Second edition. John Wiley & Sons, New York, 1939. Leather, 5 × 8 in., 340 pp., diagrams, charts, tables, $2.75. The purpose of this work is to provide, in a book designed to fit the pocket, a collection of engineering formulas, mathematical operations, and tables that are constantly wanted by engineers and students of engineering. This edition has been revised and extended, and the chapter on heat rewritten. The chapter on electricity has been largely rewritten also.

Entstaubungs- und Lüftungsfragen in der Werkstatt. By R. Nagel. Second edition. V.D.I. Verlag, Berlin, 1938. Paper, 6 × 8 in., 28 pp., illus., diagrams, charts, tables, 2 rm. This is a brief account of methods for dust removal and ventilation in workrooms, intended to acquaint managers with the principles and with accepted practice. The illustrations show typical installations, ventilating machinery, dust collectors, etc.

Fan Engineering, an Engineer's Handbook, edited by R. D. Madison. Fourth edition. Buffalo Forge Co., Buffalo, N. Y., 1938. Leather, 4 × 7 in., 739 pp., illus., diagrams, charts, tables, $4. This handbook presents information of use to designers and users of fans and air conditioning and ventilating apparatus. Section one on the physics of air discusses the properties of air, fluid flow, the flow of air in pipes and fans, and noise. Section two describes the uses of fans in air conditioning, drying and in boiler plants, and for removing dust. The final section contains performance tables, dimensions, etc., of fans and air-conditioning equipment.

Fettschmierung. By F. Traeg. V.D.I. Verlag, Berlin, 1938. Paper, 6 × 8 in., 90 pp., illus., diagrams, charts, tables, 7.50 rm. Modern lubricating greases and recent developments in methods of using them are discussed in a practical manner in this book. The varieties of greases, their properties, and manufacture are described. Many kinds of lubricators are illustrated and the methods of installing them shown. A bibliography is included.

Finding List for United States Patent, Design, Trade Mark, Reissue, Label, Print, and Plant Patent Numbers. By M. Randall and E. B. Watson. University of California Press, Berkeley, Calif., 1938. Paper, 5 × 9 in., 31 pp., $0.35. This pamphlet is a handy guide to the location of any patent or trade mark. The various series of official publications in which they have appeared are listed and the numbers of the patents, etc., in each volume are stated, so that any patent may be readily found by number. A list of indexes is also included and many mistakes in numbering are corrected.

Fractional Horsepower Electric Motors. By C. G. Veinott. McGraw-Hill Book Co., New York and London, 1939. Cloth, 6 × 9 in., 431 pp., illus., diagrams, charts, tables, $3.50. This book will fill a long-felt want for a comprehensive book on fractional-horsepower motors. Eighteen major types are described, the descriptions explaining their

principles of operation, usual forms of construction, speed-torque characteristics, methods of connection, repairing, rewinding, testing, etc.

FUNDAMENTAL PRINCIPLES OF PHYSICS. By H. G. Heil and W. H. Bennett, Prentice-Hall, New York, 1938. Cloth, 6 × 9 in., 631 pp., illus., diagrams, charts, tables, $5. The subjects usually found in an elementary text are here so arranged as to facilitate increasing use of the calculus in handling problems as the book progresses. This arrangement is the result of the modern tendency to correlate the elements of calculus with fundamental principles of physics and engineering in simultaneous courses. Many problems are included.

FUNDAMENTALS OF THE PETROLEUM INDUSTRY. By D. Hager. McGraw-Hill Book Co., New York and London, 1939. Cloth, 6 × 8 in., 445 pp., illus., diagrams, charts, tables, $3.50. This book provides an admirable outline of the industry in all its phases, from the exploration of oil lands to the marketing of the refined products. In addition to a presentation of oil-field operations, the history and scope of the industry, its financial aspects, refining and transportation are discussed. The work is a very useful introduction to the subject and a background for the detailed study of various branches of it.

GEWÖHNLICHE DIFFERENTIALGLEICHUNGEN. (Sammlung Göschen Bd. 920.) By G. Hoheisel. Third edition. Walter de Gruyter & Co., Berlin, 1938. Cloth, 4 × 6 in., 126 pp., tables, 1.62 rm. This brief treatise on common differential equations considers equations of the first and higher orders, linear differential equations, and limiting value functions.

GMELIN'S HANDBUCH DER ANORGANISCHEN CHEMIE. Eighth revised edition, edited by Deutsche Chemische Gesellschaft. System-Nummer 59: EISEN, Teil C, Lfg. 1. HÄRTEPRÜFVERFAHREN. Verlag-Chemie, Berlin, 1937. Paper, 7 × 10 in., 162 pp., diagrams, charts, tables, 18.75 rm. This section of Gmelin's Handbook is devoted to methods for testing the hardness of iron and steel, and summarizes the literature to April, 1937. The first section is a comprehensive review of the various methods of testing hardness, hardness tests of welds, sheet, wire and other special materials, testing machines and the relations of hardness numbers to each other and to other mechanical properties. Finally, the methods commonly used are studied critically. The result is a comprehensive guide to our knowledge of the subject.

GMELINS HANDBUCH DER ANORGANISCHEN CHEMIE. System-Nummer 59: EISEN, Teil F II, Lfg. 1, Nachweis und Bestimmung von Fremdelementen in Eisen und Stahl. Edited by Deutsche Chemische Gesellschaft. Eighth edition. Verlag Chemie, Berlin, 1938. Paper, 7 × 10 in., 164 pp., diagrams, tables, 19.50 rm. The second section of this monograph upon the analysis of iron and steel is concerned especially with the alloying elements. A comprehensive review of the literature previous to May, 1938, is provided, covering both qualitative and quantitative methods. Full directions are given for the practically useful methods.

GMELINS HANDBUCH DER ANORGANISCHEN CHEMIE. System-Nummer 59: EISEN, Teil D, Magnetische und elektrische Eigenschaften der legierten Werkstoffe. Edited by Deutsche Chemische Gesellschaft. Eighth edition. Verlag Chemie, Berlin, 1936. Paper, 7 × 10 in., 466 pp., illus., diagrams, charts, tables, 57.75 rm. This volume provides a comprehensive summary of the literature upon the magnetic and electrical properties of the alloys of iron which appeared before September, 1936. The whole of the periodical literature is reviewed, with references to sources. Appended are several useful lists of patented alloys, grouped according to their electrical or magnetic characteristics, and a list of trade names of alloys with special properties.

GRINDING WHEELS AND THEIR USES. By J. Heywood. Penton Publishing Co., Cleveland, Ohio, 1938. Cloth, 6 × 9 in., 374 pp., illus., diagrams, charts, tables, $3. A book on the theory and practice of grinding which describes modern methods and machines in detail. The selection of wheels, methods of dressing, cylindrical, roll, internal and surface grinding, polishing and buffing, etc., are described. The book is sponsored by the Grinding Wheel Manufacturers Association and the Abrasive Grain Association.

GRUNDZÜGE DER SCHWEISSTECHNIK, KURZGEFASSTER LEITFADEN. By T. Ricken. J. Springer, Berlin, 1938. Paper, 6 × 9 in., 63 pp., illus., diagrams, charts, tables, 3.90 rm. The various methods of welding by gas, thermite, and electricity are described in this brief treatise, including auxiliary equipment. The plans, calculations, and procedures for welding construction members are covered, as well as other special applications. The two final chapters discuss the distinctive and nondistinctive testing of welded seams, with a brief note on seam-welding cost estimates.

HIGH-SPEED COMBUSTION ENGINES. Design: Production: Tests. Tenth edition of the Gasoline Motor. By P. M. Heldt. P. M. Heldt, Nyack, N. Y., 1939. Cloth, 6 × 9 in., 742 pp., illus., diagrams, charts, tables, $7. Originally entitled "The Gasoline Motor," this treatise covers the design, production, and testing of the gasoline engine in a comprehensive, practical manner. Theory and fundamentals are thoroughly explained and their application illustrated by numerous examples of modern engines. The book is intended as a textbook for students and a reference book for engineers. This edition has been thoroughly revised and largely rewritten. Many new illustrations have been added, and also chapters on carburetors and ignition equipment. Designers and constructors will find the work useful.

HISTORY OF SCIENCE, TECHNOLOGY AND PHILOSOPHY IN THE EIGHTEENTH CENTURY. By A. Wolf. Macmillan Co., New York, 1939. Cloth, 6 × 10 in., 814 pp., illus., diagrams, $8. In this volume Dr. Wolf continues his valuable work by discussing advances in knowledge during the eighteenth century. A full, profusely illustrated account is given of the progress made during the century in all the sciences and in technology. There is much to interest the engineer in the descriptions of advances in the testing of materials, the development of structural and road and canal building, power plant and machinery, mining, metallurgy, etc. The book is eminently readable and the illustrations, from contemporary works, add much to the interest of the narrative.

INDUSTRIAL FABRICS, a Handbook for Engineers, Purchasing Agents and Salesmen. By G. B. Haven. Second edition, revised and enlarged. Wellington Sears Co., New York, 1938. Leather, 6 × 8 in., 741 pp., illus., diagrams, charts, tables, $2. This handbook aims to present information about physical properties of these fabrics which is commonly wanted by buyers and sellers. Starting with a description of the types of cotton, the book discusses the manufacturing processes for cotton fiber, cotton yarn, the uses of industrial fabrics, their organization and properties, laboratory design and practice, and specifications and test methods. This edition has been revised and enlarged.

INTERNAL COMBUSTION ENGINE. By C. F. Taylor and E. S. Taylor. International Textbook Co., Scranton, Pa., 1938. Cloth, 6 × 9 in., 322 pp., illus., diagrams, charts, tables, $3.50. The object of this volume is to furnish a basic understanding of the functioning of the internal-combustion engine which may serve as a foundation for design or research. Both spark-ignition and compression-ignition engines are discussed. Thermodynamic properties and engine capacity receive particular attention. There is a large, classified bibliography.

INTRODUCTION TO MODERN STATISTICAL METHODS. By P. R. Rider. John Wiley & Sons, New York, 1939. Cloth, 6 × 9 in., 220 pp., diagrams, charts, tables, $2.75. This textbook discusses and explains the most widely used of the methods developed by Professor R. A. Fisher, and illustrates their application by comparatively simple numerical examples. The fundamental concepts of statistics are developed in the earlier chapters, so that the work is suitable for a first course in the subject, as well as for those with some knowledge who wish insight into modern methods.

(An) INTRODUCTION TO THE THEORY OF NUMBERS. By G. H. Hardy and E. M. Wright. Clarendon Press, Oxford, England; Oxford University Press, New York, 1938. Cloth, 6 × 10 in., 403 pp., charts, diagrams, tables, $8. Not a systematic treatise on the theory of numbers, this book comprises a series of introductions to the many sides of that theory. The list of chapter subjects includes series of primes, irrational numbers, congruences and residues, decimal representation, continued fractions, arithmetical functions, partitions, representation of a number by squares, cubes, and higher powers, and various special theorems.

INTRODUCTION TO VECTOR ANALYSIS FOR PHYSICISTS AND ENGINEERS. By B. Hague. Chemical Publishing Co., New York, 1939. Cloth, 4 × 7 in., 118 pp., diagrams, $1.50. This monograph is intended to provide an introduction to those elementary principles most used by physicists and engineers which will meet the needs of busy workers who approach the subject for the first time. A physical, rather than a mathematical point of view is adopted in the explanations.

JAHRBUCH 1938 DER DEUTSCHEN LUFTFAHRTFORSCHUNG unter Mitwirkung des Reichsluftfahrtministeriums und der Luftfahrtforschungsanstalten. Sections paged separately, 50 rm. "Ergänzungsband," 403 pp., 24 rm. R. Oldenbourg, Munich and Berlin, 1938. Cloth, 8 × 12 in., illus., diagrams, charts, tables. The first of these two large volumes provides an account of developments in aviation research during 1938, under the direction of the German government and the various universities and technical colleges. The various investigations are presented in full. The supplementary volume contains the papers presented at the 1938 meeting of the Lilienthal Gesellschaft für Luftfahrtforschung by German and foreign engineers. Those by foreign engineers are given in the original language, with a translation into German.

KEMPE'S ENGINEER'S YEAR-BOOK 1939. Forty-fifth annual issue, revised under the direction of L. St. L. Pendred. Morgan

Bros., London, 1939. Leather, 5 × 7 in., 2824 pp., illus., diagrams, charts, tables, 31s. 6d. An annual British publication covering modern practice in civil, mechanical, electrical, marine, gas, aero, mine, and metallurgical engineering. In addition to explanatory technical information in these fields the book contains useful formulas, rules, tables, and other engineering data. There are also sections on patents, depreciation, legal questions, and costs. Some 230 pages are devoted to descriptions of particular pieces of engineering equipment.

KUNSTSTOFFE. Im Auftrage des Fachausschusses für Kunst- und Pressstoffe des Vereines deutscher Ingenieure. Edited by F. Pabst and R. Vieweg. V.D.I. Verlag, Berlin, 1938. Paper, 6 × 8 in., 92 pp., illus., diagrams, tables, 3 rm. This brief treatise on artificial materials covers cellulose derivatives, synthetic resins and other plastics, and synthetic rubber. The methods of producing and working these substances are given; their technical, economic, and artistic aspects are discussed; and methods of testing by mechanical, electrical, thermal, optical, and chemical means are described.

LEHRBUCH DER MATHEMATIK. By G. Scheffers. Seventh edition. Walter de Gruyter & Co., Berlin, 1938. Cloth, 6 × 10 in., 743 pp., diagrams, charts, tables, 15 rm. This book is intended for those with an elementary knowledge of algebra and geometry who wish to gain by home study a working knowledge of higher algebra, analytical geometry, the calculus, and various mathematical functions, either for practical use or as a basis for advanced study.

LOCOMOTIVE CYCLOPEDIA of American Practice, compiled and edited by the Association of American Railroads, Mechanical Division. Simmons-Boardman Publishing Corporation, New York, 1938. Paper, 8 × 12 in., 1232 pp., illus., diagrams, charts, tables. The tenth edition of this well-known reference work follows the general lines of the preceding one, but numerous improvements in arrangement and indexing facilitate use. It has also been thoroughly revised and brought up to date by the inclusion of new designs. The section on locomotive shops and engine terminals has been entirely rewritten and now presents a comprehensive account of current practice in locomotive maintenance.

MAKING AND MOULDING OF PLASTICS. By L. M. T. Bell. Revised edition. Chemical Publishing Co., New York, 1938. Cloth, 6 × 9 in., 242 pp., illus., diagrams, charts, tables, $5. The fundamental materials and the important processes of plastic molding are briefly and simply discussed, together with hydraulic plant and equipment, mold design and construction, inspection and testing. Probable future developments are suggested.

MANUAL FOR EXECUTIVES AND FOREMEN. By E. H. Schell and F. F. Gilmore. McGraw-Hill Book Co., New York and London, 1939. Cloth, 5 × 8 in., 185 pp., tables, $2. This manual gives step-by-step procedures for improving the departmental process, the workplace, the work, the attitude of employees, and the control of quantity, quality, equipment, and storage. The recommendations are very practical and the methods given have been tested and found effective.

MANUFACTURE OF PULP AND PAPER, Vol. 5. Prepared under the direction of the Joint Textbook Committee of the Paper Industry of the United States and Canada. Third edition. McGraw-Hill Book Co., New York and London, 1939. Cloth, 6 × 9 in., sections paged separately, illus., diagrams, charts, tables, $6.50. This well-known textbook, an official work of the paper industry of the United States and Canada, concludes the account of papermaking begun in volume four of the series. Papermaking machines, handmade papers, paper finishing, coated papers, paper testing, and papermaking details are discussed clearly and practically. This edition has been thoroughly revised.

MARCH OF THE IRON MEN. By R. Burlingame. Charles Scribner's Sons, New York and London, 1938. Cloth, 6 × 10 in., 500 pp., illus., $3.75. Primarily, Mr. Burlingame's object is to write "the history of the evolution of that social pattern which produced a nation from the United States." This he undertakes to do in terms of the factor of technological invention, this being the factor that he considers first in importance. The result is an interesting, useful account on a broad scale of the progress of American invention from its beginnings to our own times, which will be welcomed by students of engineering history. A good bibliography is provided, as well as a chronological list of important inventions and events in American history.

MATHÉMATIQUES GÉNÉRALES. (Aide-Mémoire Dunod.) By Maurice-Denis Papin. Dunod, Paris, 1939. Cloth, 4 × 6 in., 274 pp., diagrams, tables, 25 fr. The subject matter of this small pocketbook of descriptive and tabular information covers algebra, plane and solid geometry, plane and spherical trigonometry, analysis of functions, the calculus, differential equations, probabilities, analytic geometry, infinitesimals, graphical methods, and vectors.

MECHANISM. By R. M. Keown and V. M. Faires. Fourth edition. McGraw-Hill Book Co., New York and London, 1939. Cloth, 6 × 9 in., 282 pp., illus., diagrams, charts, tables, $2.75. The motions of fundamental mechanisms and their combinations, including the manner of supporting and guiding machine parts, are presented for elementary study. Major topics covered include friction wheels, belts, cams, gearing, and theoretical discussion of velocities and accelerations. Numerous problems accompany each chapter.

METALLOGRAPHIC TECHNIQUE FOR STEEL, a series of three educational lectures on metallographic technique for steel, presented to members of the A.S.M. during the nineteenth National Metal Congress and Exposition, Atlantic City, New Jersey, Oct. 18–22, 1937. By J. R. Vilella. American Society for Metals, Cleveland, 1938. Cloth, 6 × 9 in., 84 pp., illus., $2. The three lectures reprinted in this book cover, respectively, the preparation of the specimen; etching methods; and photomicrography. The principal object is to acquaint the metallographer with the proper appearance of steel structure under varying conditions, and to demonstrate the differences between good and poor technique.

METALS. Two volumes. By Sir H. Carpenter and J. M. Robertson. Oxford University Press, New York and London, 1939. Cloth, 6 × 10 in., 1485 pp., illus., diagrams, charts, tables, $35. The aim of this treatise is to present a systematic, comprehensive account of the industrially important metals and alloys from the point of view of the relations between treatment, characteristics, and properties. Part one describes the characteristics of pure metals, their microstructure and crystal structure, and their behavior when subjected to the action of force. Part two is devoted to the theory of alloys. Part three deals with the mechanical properties of metals and their resistance to oxidation and corrosion. Part four discusses the influence of treatment on these characteristics and properties. Parts five and six deal specifically with the industrially important ferrous and nonferrous metals and alloys. The book provides a logical, readable account of the present state of knowledge which will be of value to all students of the subject and will form a useful background for specialized reading and research work.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN des Gutehoffnungshütte - Konzerns, Bd. 6, Heft 10, December, 1938, pp. 259–278, V.D.I. Verlag, Berlin. Paper, 8 × 12 in., illus., diagrams, charts, tables, 2.45 rm. The communication from the Research Institute of the Gutehoffnungshütte-Konzern contains three articles covering, respectively, an entropy diagram for fire damp, an investigation of the pulsating tensile-fatigue strength of flash-welded connections, and a description of the by-product plant of the Osterfeld coke works of the Gutehoffnungshütte.

MODERN DEVELOPMENTS IN FLUID DYNAMICS, an Account of Theory and Experiment Relating to Boundary Layers, Turbulent Motion, and Wakes. Two volumes. Edited by S. Goldstein. Clarendon Press, Oxford, England; Oxford University Press, New York, 1938. Cloth, 6 × 10 in., 702 pp., illus., diagrams, charts, tables, $16. The purpose of this work is to present and summarize methods of experiment and development of theory in certain branches of hydrodynamics of special interest to aeronautical science. It discusses the laminar and turbulent flow of viscous fluids and the transfer of heat in such flow, as well as modern theories concerning it. Mathematical solutions of types of flow are given, and experimental methods are described. The book has been composed by the Fluid Motion Panel of the Aeronautical Research Committee, with the collaboration of several experts.

MOTOR VEHICLE. By K. Newton and W. Steeds. Second edition, published from the offices of the *Automobile Engineer*, Iliffe & Sons, Ltd., London, 1938. Cloth, 6 × 9 in., 492 pp., illus., diagrams, charts, tables, 10s 6d. The opening chapters of this descriptive textbook present fundamental information on engineering drawings, bearings and gearing, mechanics, and heat engines. The following chapters describe and explain the various types of motor engines, including the compression-ignition engine, and also deal with such specific topics as carburetion, fuel supply, lubrication, cooling, transmission, gearing, brakes, springing, frame construction, etc.

DIE ORTSFESTEN ANLAGEN ELEKTRISCHER BAHNEN. By K. Sachs. Orell Füssli Verlag, Zurich and Leipzig, 1938. Cloth, 8 × 11 in., 321 pp., illus., diagrams, charts, tables, 29 rm, 48 Swiss fr. The construction of electric railways is presented with unusual detail in this valuable treatise, which is based upon familiarity with current practice throughout the world. Starting with the power station and its equipment, the author successively discusses transmission lines, substations, overhead and third-rail conductors, signal systems, and car heating and lighting. The book is profusely illustrated with drawings and photographs.

PATTERN MAKING. By J. Ritchey. Revised by W. W. Monroe, C. W. Beese, and P. R. Hall. American Technical Society, Chicago, 1939. Cloth, 6 × 9 in., 233 pp., illus., diagrams, charts, tables, $2. The essentials of patternmaking are fully considered, covering tools and equipment, simple and complicated pat-

terns for typical cases, the use of green and dry sand cores, and metal patternmaking. Certain special problems of design are treated.

PERCEPTION OF LIGHT. By W. D. Wright. Chemical Publishing Co., New York, 1939. Cloth, 5 × 8 in., 100 pp., diagrams, charts, $2.50. A concise analysis of the visual phenomena of most importance to lighting engineers and others concerned with lighting problems. Special attention is paid to purely physiological investigations in this field. Among the topics considered are vision at low and high intensities, glare, and visual sensations.

PETROLEUM COMES OF AGE. By A. A. Lawrence. Scott-Rice Co., Tulsa, Okla., 1938. Cloth, 6 × 9 in., 227 pp., illus., maps, $2.25. This volume gives an interesting account of the oil history of the two Oil Creek regions tributary to the Allegheny River—one in New York, the other in Pennsylvania. Developments are traced from the earliest mention of oil in this region down to the year 1881, including some account of the technical changes in transportation and refining. A bibliography is included.

PHOTOGRAPHIC CHEMICALS AND SOLUTIONS. By J. I. Crabtree and G. E. Matthews. American Photographic Publishing Co., Boston, Mass., 1939. Cloth, 6 × 9 in., 360 pp., illus., diagrams, charts, tables, $4. The importance of certain solutions in photographic work makes a knowledge of the fundamental principles of their preparation and use valuable to the user. The purpose of this book is to supply such information, including the properties of the chemicals, the chemical reactions involved, and specific methods of handling both small and large quantities of chemicals.

PHYSIK. By P. Wessel and V. R. von Paar. Ernst Reinhardt, Munich, 1938. Leather, 5 × 8 in., 514 pp., diagrams, charts, tables, 4.90 rm. This college textbook, which covers the customary topics included in physics courses, uses many illustrations and heavy-line boxes around certain equations to clarify and emphasize important points. A review section and a large group of test questions, with references to the appropriate sections of the text, increase the practical value of the text, as does the detailed index.

PLASTIC WORKING OF METALS AND POWER-PRESS OPERATIONS. By E. V. Crane. Second edition. John Wiley & Sons, Inc., New York, 1939. Cloth, 6 × 9 in., 450 pp., illus., diagrams, charts, tables, $5. The characteristics common to the different groups of metal-working operations are discussed and a working theory established. Since all the operations described act to stress the metal beyond its elastic limit, the assembling and development of theoretical data on metal properties within this range constitute an important part of the book. Many useful tables are contained in an appendix, along with some thirty pages of explanation and description of various graphical computations.

PLASTICS, Problems and Processes. By D. E. Mansperger and C. W. Pepper. International Textbook Co., Scranton, Pa., 1938. Leather, 6 × 9 in., 187 pp., illus., diagrams, charts, tables, $2.50. This book is intended for students in industrial-art schools and amateurs who wish to work in plastics. It gives practical detailed instruction about tools for working plastics and methods of forming and finishing them. Working drawings and directions for making a large number of useful articles are provided. Appended are a list of trade names and makers, a directory of supply sources, a glossary, and a bibliography.

PROBLEMS IN PUBLIC UTILITY ECONOMICS AND MANAGEMENT. By C. O. Ruggles. Second edition. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9$^1/_2$ in., 772 pp., diagrams, charts, tables, $6. Important problems that arise in public-utility management are presented for analysis and illustrated by actual cases. The questions considered include the economic characteristics of public utilities; their production problems; management, organization, and finance; wholesale marketing of service; retail marketing; valuation, rate making, and fair return; and regulation and management.

PROCEEDINGS OF THE RUBBER TECHNOLOGY CONFERENCE held under the auspices of the Institution of the Rubber Industry, May 23–25, 1938, Hotel Victoria, London, England. Edited by T. R. Dawson and J. R. Scott. W. Heffer & Sons, Cambridge, England, 1938. Cloth, 7 × 10 in., 1137 pp., illus., diagrams, charts, tables, £2 2s. This conference was held in London in May, 1938, and participated in by official delegates from 89 organizations representing 16 countries. One hundred and three papers were presented and appear, with the discussions, in this volume. Applications, chemistry, compounding materials, durability, general technology, latex, physics, plantation subjects, and rubber-like synthetic materials were discussed.

PSYCHOLOGY FOR BUSINESS AND INDUSTRY. By H. Moore. McGraw-Hill Book Co., New York and London, 1939. Cloth, 6 × 9 in., 527 pp., illus., diagrams, charts, tables, $4. This book discusses practical business problems and calls attention to the contribution of psychology to their solution. The selection of employees and methods of testing fitness, training, and promoting workers, accident prevention, fatigue, and psychological problems in advertising and selling are considered and constructive suggestions are made.

PUBLIC UTILITY REGULATION. By G. L. Wilson, J. M. Herring, and R. B. Eutsler. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9 in., 571 pp., tables, $4. An analysis of the nature, extent, and problems of public-utility regulation is presented. The authors first consider historical development and the emergence of the state public-utility commission as the prevailing pattern of regulatory machinery. Federal government control is described and analyzed, and the issues of government versus private ownership are evaluated.

REFRIGERATING DATA BOOK, Vol. 1. Refrigerating Principles and Machinery. Fourth edition. American Society of Refrigerating Engineers, New York, N. Y., 1939. Cloth, 6 × 10 in., 527 pp. (Refrigerating Catalog & List of A.S.R.E. Members Section, 134 pp.), illus., diagrams, charts, tables, $4 in U.S.A., $4.50 in foreign countries. This publication, the work of many experts, brings together all the essential information and numerical data on refrigeration and air conditioning. This edition has been thoroughly revised and many chapters rewritten, including those on compression and absorption systems, dry ice, fluid flow, insulation, and small air-conditioning machinery. An appendix gives a directory of equipment manufacturers and distributors, and a list of members of the Society.

SAMPLING AND ANALYSIS OF CARBON AND ALLOY STEELS. Reinhold Publishing Corporation, New York, 1938. Cloth, 6 × 9 in., 356 pp., diagrams, tables, $4.50. This collection of methods represents the practice of the chemists of the subsidiary companies of the United States Steel Corporation. The text covers the whole range of determinations required in the steelworks' laboratory, and includes detailed directions for the methods that have been found most satisfactory.

Schweiz. Verband für die Materialprüfungen der Technik (Association Suisse pour l'Essai des Matériaux), Bericht Nr. 36. RÉSISTANCE ET STRUCTURE MICROSCOPIQUE DES BOIS, by P. Jaccard and A. Frey-Wyssling. Schweiz. Verband, etc., Zürich, May, 1938. Paper, 8 × 12 in., 32 pp., illus., diagrams, charts, tables. The variation of strength of certain woody fibers under various conditions, the lignification of wood with its physical and physiological consequences, and a technical investigation of the microscopic structure of wood, are the topics of the three papers forming this report of the Swiss Materials Testing Institute.

SILICOSIS AND ASBESTOSIS, by various authors, edited by A. J. Lanza. Oxford University Press, London and New York, 1938. Cloth, 6 × 9 in., 439 pp., illus., tables, $4.25. A comprehensive presentation of the medical and public-health aspects of these industrial dust diseases is provided in this work, to which several physicians have contributed. The history of the diseases, their symptoms and diagnosis, their pathology, and their prevalence in various occupations are discussed, as well as methods of prevention and control. Each section has a bibliography.

SPANNUNGSMESSUNG AN WERKSTÜCKEN. (Ergebnisse der Technischen Röntgenkunde, Bd. 6, ed. by J. Eggert and E. Schiebold.) By E. Schiebold. Akademische Verlagsgesellschaft, Leipzig, 1938. Cloth, 6 × 9 in., 216 pp., illus., diagrams, charts, tables, 18.80 rm. This book discusses various questions involved in the investigation and measurement of stresses in metals by X-ray and optical methods and outlines the use of these as practical test methods. Thirteen contributions by various experts are included.

STEAM-ENGINE PRINCIPLES AND PRACTICE. Edited by T. Croft, revised by E. J. Tangerman. Second edition. New York and London, McGraw-Hill Book Co., 1939. Cloth, 6 × 8 in., 513 pp., diagrams, charts, tables, $3.50. A clear, practical text for the operating engineer and plant superintendent, which has been thoroughly revised and amplified to represent current practice. The selection, operation, maintenance, and repair of engines are covered in detail.

STEEL AND ITS HEAT TREATMENT. Vol. 1. Principles, Processes, Control. By D. K. Bullens. Fourth edition, rewritten. John Wiley & Sons, New York, 1938. Cloth, 6 × 9 in., 445 pp., illus., diagrams, charts, tables, $4.50. This edition represents a thorough revision and an extension of this well-known text, carried out by the staff of the Battelle Memorial Institute. The work now appears in two volumes, of which the first discusses the principles that underlie the heat-treatment of steel, the surface-reaction processes in use, and the control of heat-treating operations. The work aims to give a broad, practical picture of the heat-treatment of steel and the principles involved. Each chapter has a bibliography.

STEEL AND ITS HEAT TREATMENT. Vol. 2, Engineering and Special-Purpose Steels. By D. K. Bullens and the Metallurgical Staff of the Battelle Memorial Institute. Fourth edition. John Wiley & Sons, Inc., New York, 1939. Cloth, 6 × 9 in., 491 pp., illus., diagrams, charts, tables, $5. The second volume of this new edition deals with carbon

and alloy steels for engineering and other special purposes. Special attention has been given to the characteristics of the alloying elements, the special properties that these confer upon steel, and the variations in heat-treatment required to utilize alloy steels most fully and economically. The revision of this edition has been done by the metallurgical staff of the Battelle Memorial Institute.

1938 SUPPLEMENT TO BOOK OF A.S.T.M. STANDARDS. American Society for Testing Materials, Philadelphia, 1938. Paper, 6 × 9 in., 241 pp., diagrams, charts, tables, $2. This is the second supplement to the 1936 Book of Standards. It contains thirty-two new standards and twenty-five revisions of existing ones, adopted in September, 1938.

SYMPOSIUM ON IMPACT TESTING. American Society for Testing Materials, Philadelphia, 1938. Paper, 6 × 9 in., pp. 21–177, illus., diagrams, charts, tables, $1.25. This pamphlet contains the papers and discussions presented at a meeting in June, 1938. Attention was concentrated upon the present fields of commercial use for the impact test, with particular references to fields where it gives necessary information not supplied by static tests, and upon the basic theory underlying the test.

TECHNOLOGY OF SOLVENTS. By O. Jordan, translated by A. D. Whitehead for Technical Service Library, London; distributed by Chemical Publishing Co., New York, 1938. Cloth, 6 × 10 in., 351 pp., diagrams, charts, tables, $10. The general section of this translated German work discusses fundamental definitions and classification, physical properties, solvents for various kinds of materials, solvents for extraction, plasticizers, solvent recovery, and the analysis, manufacture, and physiological action of solvents. The special section describes individual solvents and plasticizers. There are many useful tables, a key to proprietary names, and a patent index.

THEORETICAL MECHANICS, a Vectorial Treatment. By C. J. Coe. The Macmillan Co., New York, 1938. Cloth, 6 × 9 in., 555 pp., diagrams, tables, $5. The basic principles of vector analysis are explained and applied to classical mechanics, and through it to mathematical physics, the simple postulates on which these are based having first been made clear. Starting with simple geometry the subject matter carries through concepts of increasing difficulty up through potential theory.

THEORY OF EQUATIONS. By J. M. Thomas. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 8 in., 211 pp., diagrams, tables, $2. A textbook for a course in the theory of algebraic equations for advanced undergraduate and graduate students. The treatment, though elementary, is in accord with "modern algebra." It covers certain topics seldom found in texts on the subject, and forms an approach to the Galois theory and other more advanced phases of algebra.

THORPE'S DICTIONARY OF APPLIED CHEMISTRY, Vol. 2. By J. F. Thorpe and M. A. Whiteley. Fourth edition. Longmans, Green & Co., New York and London, 1938. Leather, 6 × 9 in., 711 pp., illus., diagrams, tables, $25. A continuation of the fourth edition of this valuable work, covering the section "Bl–Chemical Analysis." Although the subject matter is arranged in dictionary style, the more important subjects are treated in monograph form with bibliographic references. The intention is to give a concise and readable account of the condition of modern chemistry which will be of use to both expert and layman.

TIME STUDY FOR COST CONTROL. By P. Carroll, Jr. McGraw-Hill Book Co., New York, 1938. Cloth, 6 × 10 in., 305 pp., diagrams, charts, tables, $3. A practical method is outlined in detail for completing the time-study measurement and control of cost without rearranging the shop. The preparation and use of standard data precede changes rather than follow them, as is the case with individual operation time study. The author shows the logical extension of the method to form the basis for many managerial controls.

DIE VERBRENNUNGSKRAFTMASCHINE, edited by H. List. Heft 1. Vorwort und Einführung, by H. List. Die Betriebsstoffe für Verbrennungskraftmaschinen, by A. v. Philippovich. Die Gaserzeuger, by K. Schmidt. Julius Springer, Vienna, 1939. Paper, 7 × 11 in., 106 pp., illus., diagrams, charts, tables, 9.60 rm. This is the first of a series of works produced under Dr. List's editorship and designed collectively to form a comprehensive modern treatise on internal-combustion engines. This installment contains a brief introduction, by Dr. List; internal-combustion engine fuels and oil, by Dr. A. von Philippovich; and gas producers, by Kurt Schmidt. The subjects are discussed practically, from the viewpoint of the manufacturer, and on the basis of recent research and manufacturing experience. There are bibliographies.

DIE VERBRENNUNGSKRAFTMASCHINE, edited by H. List. Heft 7. Gemischbildung und Verbrennung im Dieselmotor, by A. Pischinger and O. Cordier. Julius Springer, Vienna, 1939. Paper, 8 × 11 in., 128 pp., diagrams, charts, tables, 12.60 rm. This section on the internal-combustion engine is a thorough discussion of fuel mixtures and combustion. Ignition and combustion, and the regulation and distribution of fuel within and without the cylinder are treated. Chiefly, the book is devoted to injection phenomena and equipment. There is a bibliography.

VERTICAL STEAM ENGINE. (Instructions in Engineering Design, Vol. 1.) By H. P. Philpot. Longmans, Green & Co., London and New York, 1937. Paper, 6 × 10 in., 100 pp., diagrams, charts, tables, $1.50. This publication constitutes a sample of an actual design for a two-cylinder vertical steam engine. Using the notes as a guide, the student is to design an engine for a different horsepower. A brief résumé of fundamentals precedes the design calculations.

V.D.I. Forschungsheft 393: REIBUNG UND TEMPERATURVERLAUF IM GLEITLAGER, by A. Rumpf. V.D.I. Verlag, Berlin, 1938. Paper, 8 × 12 in., 24 pp., illus., diagrams, charts, tables, 5 rm. An investigation of the relation between friction and load, speed, and temperature in plain bearings is the subject of this publication. Test conditions and results are given, as well as theoretical considerations, and the characteristics of various forms of bushings are compared.

V.D.I. Forschungsheft 394. Zur SYNTHESE EBENER UND RÄUMLICHER KURBELTRIEBE. By R. Beyer. V.D.I. Verlag, Berlin, 1939. Paper, 8 × 12 in., 22 pp., diagrams, tables, 5 rm (to members, 4.50 rm). Discussion with diagrams pertaining to the synthesis of plane and three-dimensional crank drives, giving consideration to the respective and successive motions and positions of linkage members.

VORTRÄGE DER HAUPTVERSAMMLUNG 1938 DER DEUTSCHEN GESELLSCHAFT FÜR METALLKUNDE, edited by Deutsche Gesellschaft für Metallkunde. V.D.I. Verlag, Berlin, 1938. Paper, 8 × 12 in., 113 pp., illus., diagrams, charts, tables, 6 rm. The papers delivered at the 1938 meeting of the society are collected in this volume. The theme of the meeting was "materials testing as the basis of the development and use of metals and alloys," and the papers generally discuss various testing procedures, their present state, and future development.

WELDING ENCYCLOPEDIA. 1938. Compiled and edited by L. B. Mackenzie and H. S. Card. Ninth edition. Welding Engineer Publishing Co., Chicago. Leather, 6 × 9 in., 696 pp., illus., diagrams, charts, tables, $5. In this new revised edition the subject matter is arranged alphabetically with cross references. The principal topics covered include the main types of welding, the most important fields of use, metals and alloys, metal spraying, rules, codes and specifications, tables and charts of engineering data, testing methods, and operator training. Company names are included with a listing of the trade names of their products.

WERKZEUGVERSCHLEISS, insbesondere an DREHMEISSELN. (Berichte über betriebswissenschaftliche Arbeiten, Bd. 11.) By H. Schallbroch and R. Wallichs. V.D.I. Verlag, Berlin, 1938. Paper, 8 × 12 in., 35 pp., illus., diagrams, charts, tables, 6.50 rm. The results of investigations in the wear of tools, particularly lathe tools, in working some of the newer metals and alloys appear in this report. Information is given concerning the factors which influence tool wear and those which are influenced by tool wear. General considerations are also briefly surveyed.

Wissenschaftliche Abhandlungen der Deutschen Materialprüfungsanstalten (formerly: Sonderhefte der Mitteilungen der Deutschen Materialprüfungsanstalten), Folge 1, Heft 2. Die BEARBEITUNG VON FRAGEN DER SCHWEISSTECHNIK AN DEN DEUTSCHEN MATERIALPRÜFUNGSAMTERN, Stand ende 1938. Julius Springer, Berlin, 1939. Paper, 8 × 12 in., 95 pp., illus., diagrams, charts, tables, 19.60 rm. The various new and reprinted articles included in this collection are concerned with the research work in the German testing laboratories which resulted from the substitution of welded for riveted joints. They are separated into three groups: interrelation of construction, structural elements, and materials to the use of welded joints; mechanical testing of welded joints with respect to the influence of certain operations on their strength; and, the inspection of welded joints by nondestructive test methods.

WOOD PULP. By J. Grant. Chronica Botanica Co., Leiden, Holland; G. E. Stechert & Co., New York, 1938. Paper, 6 × 10 in., 209 pp., diagrams, tables, 7 guilders (about $4.50). A work on wood pulp and the uses to which it is put, which affords an accurate, comprehensive view of the subject, without attempting to be exhaustive. There is a bibliography.

WORKING AND HEAT-TREATING OF STEEL. By R. H. Harcourt. Stanford University, Calif., 1938. Cloth, 6 × 9 in., 261 pp., illus., diagrams, charts, tables, $3.75. The aim of this textbook is to supply a concise account of the principles and methods involved in making, working, and heat-treating steel, for use in technical schools and colleges.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Fourteen Technical Sessions for A.S.M.E. Semi-Annual Meeting at San Francisco, July 10–15

SEVEN Divisions of The American Society of Mechanical Engineers have been working for a year to develop a technical program of such unusual merit that members from all parts of the United States and Canada would be justified in attending the 1939 Semi-Annual Meeting to be held in San Francisco, July 10 to 15. And a quick look over the sessions which have been arranged shows that the various committees have done a good job of it.

Technicalities

The Aeronautic Division is to have a session dealing with transportation across the Pacific and this would seem to be extremely timely. Papers are being arranged with leaders in the aeronautic field. The fuels of California, oil and natural gas, will provide papers on the problems of burning these types of fuel and the apparatus best adapted for their use. The heat-transfer session will deal with the best type of insulation for intermittent service.

Hydraulics and hydraulic equipment are so essential a part of any technical program which the A.S.M.E. presents on the Pacific Coast that two sessions have been planned with papers on modern impulse-type turbines, automatic check and control valves on the Colorado River Aqueduct, flow of water in channels under steep gradients, and an analogy between hydrodynamics and heat transmission in fluids.

The organization and labor problems of branch-plant management will account for interesting management sessions. The Oil and Gas Power Division is most pleased to be able to announce that Dr. Adolph Meyer, of Brown, Boveri & Co., has promised to make the trip from Switzerland to present a paper on gas-turbine problems.

In the processing field a session on mechanical separation will have papers on electrostatic separation, air classifiers, and mechanical separation of gases. Another session on agricultural engineering will cover engineering factors in agricultural technology, quick freezing of fruits and vegetables, heat transmission in dairy pasteurizers, and water regimen of soils in place in the field.

Two papers on cooling towers will round out an unusually fine program.

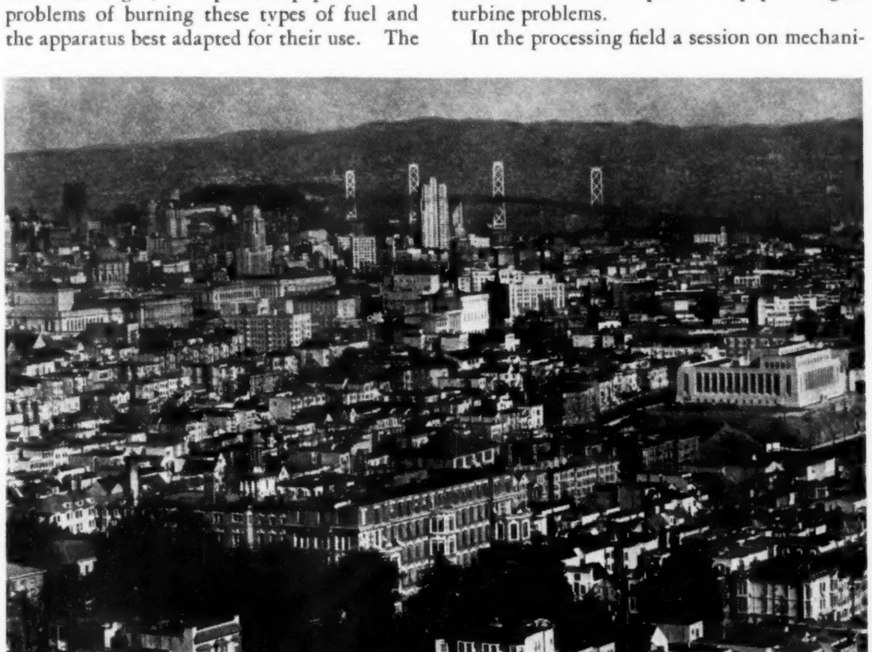
In addition, members of the Society will have an opportunity to attend a session sponsored by the Newcomen Society. Our honored past-president, Dr. William F. Durand, will present an historical paper on the development of the Pelton water wheel which will be illustrated with lantern slides.

"Engineering Day" at the Fair

On Monday, July 10, the first day of the meeting the Council of the Society and various committees will meet. Technical sessions will be held all day Tuesday and on Wednesday and Friday mornings. Thursday will be "Engineering Day" at the Fair. In addition to special features at the technical exhibits, there will be an all-engineers' banquet on Treasure Island at which will be speakers of national reputation. Their names and subjects of their talks will be published in the June issue of MECHANICAL ENGINEERING.

Hotel Accommodations

Members who think they may wish to attend this meeting are urged to advise Oliver B. Lyman, chairman A.S.M.E. Hotel Committee, Fairmont Hotel, Nob Hill, San Francisco, Calif., sending a carbon copy, if convenient, to the Secretary's office, 29 West 39th Street, New York. Over three hundred rooms are reserved at seven hotels. If the accommodations you desire, or the rates you indicate are not available at the Fairmont Hotel, the Hotel Committee will assign you to the best available space in another of the following hotels: Mark Hopkins where the rates are from \$5 to \$7 daily for one or two persons; Hotel Whitcomb, one and two persons, \$2 to \$3; Hotel Golden State, double rooms \$3.50; Hotel Chancellor, double rooms, \$2.25 to \$3; Hotel Cartwright, one and two persons, \$3 to \$2.50; Hotel Bellevue, double rooms \$2.50 to \$5. The official hotel headquarters at the Fairmont quote single rates \$4 to \$7 and double rates from \$7 to \$15, with parlor suites at \$20 and \$30. Generally hotel reservations are considered to be secure only until ten days prior to the start of the meeting. Rooms will be assigned in the order in which the reservations are received, and members are especially requested to cooperate with the committee by giving early notice of their intention to attend. If your



AIR VIEW OF SAN FRANCISCO WITH OAKLAND BAY BRIDGE, ONE OF THE WORLD'S MOST FAMOUS BRIDGES, IN THE BACKGROUND

plans must be changed later you can easily cancel your reservations, so that you are not obligating yourself financially by giving prompt notice, but you are cooperating with a hardworking committee and also giving yourself a better selection of rooms at the same price or perhaps even a lower price than you will be called upon to pay later.

The American Institute of Mining and Metallurgical Engineers will meet in San Francisco the same week. However, the real threat on room shortage comes because of the fact that ten thousand lawyers threaten to invade the Golden Gate City that week. Watch for further details in the June issue and meanwhile write to the Secretary's office for any further information or assistance you may desire.

Cost of Tour

The total cost *per person* for this trip omitting the cost of meals for the five days in San Francisco, but including hotel accommodations at the Fairmont Hotel which will be headquarters for the Meeting, will be approximately $480 plus $125 for the Alaska trip. This is on the basis of two persons occupying a compartment on the train, a twin-bed double room with bath at hotels, and the minimum rate on the steamer. Obviously, there will be a variation in rates according to the accommodations selected. Therefore, members asking for information should state their preference as to train and hotel accommodations. If there are a sufficient number of members who desire to save approximately $25 a person for the trip by occupying tourist sleepers west of Chicago this can be arranged. It will also be possible to save somewhat by occupying a lower or an upper berth; this arrangement will be possible only if there are a sufficient number of persons interested to make it advantageous to add equipment of this type. In the past these tours have carried only compartments and drawing rooms, as these accommodations have been preferred by most travelers for long distances.

Tour Open to Friends of Members

The tour will, of course, be open to friends endorsed by members of the Society but not generally open to the public. A number of A.S.M.E. Local Sections along the route are planning in one way or another to entertain members and all of the plans made thus far point to a never-to-be-forgotten trip.

A more detailed outline of the schedule follows. It should be noted that this schedule is subject to such modifications as may be found necessary or desirable between now and the time of departure.

A.S.M.E. Tour to San Francisco

All-Expense 24-Day Trip Visiting Many Points of Engineering, Scenic, and Historical Interest; Attending Semi-Annual Meeting at San Francisco; Visiting Alaska if Desired

WHAT IS believed to be an exceptionally attractive tour to the A.S.M.E. Semi-Annual Meeting at San Francisco includes visits to Rocky Mountain Park, Mt. Evans, Salt Lake City, Cedar Breaks, Zion Park, a day at Boulder Dam, Los Angeles with visits to points of engineering interest including the site of the 200-in. mirror at California Tech and Observatory at Mt. Palomar, Yosemite National Park with opportunity for those interested to visit several 500- and 600-head hydro plants; five days in San Francisco with plenty of time to visit and enjoy the Fair on Treasure Island, as well as to attend the technical sessions. The tour continues to Portland, Ore., with a visit to the Bonneville Dam after a drive over the Columbia River scenic highway, and a day at Seattle to view the beauties and attractions of that city; then on to Victoria, and Vancouver, returning via the Canadian Rockies. For those who can spend an extra week or ten days an optional trip to Alaska with a side trip from Skagway to West Taku Arm has been scheduled.

Make Your Reservations Early

Travel this summer promises to be popular according to advance reservations which have been made at various western resort points and, therefore, it is essential that you advise the office of the Secretary of the A.S.M.E. on or before May 15 if you are at all interested in this trip. Although reservations have been made for a party of a hundred persons some of these reservations must be released by May 16 unless there is a demand insuring their use. Members are encouraged and urged, therefore, to write the Secretary's office or to use the coupon appearing on page 33 of the advertising section of this issue. No obligation is incurred in so doing and no deposit for the present is required. However, it will be possible for those responsible for making the arrangements to get a fair idea of the accommodations which must be provided and to keep those who are interested in taking this tour informed as plans are completed.

COURT OF THE MOON

(The Court of the Moon at the 1939 Golden Gate International Exposition; facing the Fountain is the statue of "The Evening Star;" on the right is the Tower of the Sun.)

Tentative Itinerary

MEMBERS and their guests who plan to take this tour and who are located in New England will join the group at New York, leaving Boston as late as 8:00 a.m. (Eastern Standard Time) on the New Haven Railroad, Wednesday, June 28. This train makes stops at principal points en route and arrives at the New York Pennsylvania Station at 1:15 p.m. Those residing in the East or South where connections at New York are not convenient may join the party at Chicago or other prearranged points.

Wednesday, June 28

Leave New York (Pennsylvania Railroad), 3:40 p.m. (E.S.T.)
Leave Washington, 1:50 p.m., with stops at Baltimore and Harrisburg.
Leave North Philadelphia, 5:09 p.m.

Thursday, June 29

A sleeping car will start from Pittsburgh, open at 9:30 p.m., if a sufficient number join the party at that point.
Leave Pittsburgh, 12:20 a.m.
Arrive Chicago, 7:50 a.m.
Leave Chicago, 10:30 a.m.

Friday, June 30

Arrive LaSalle, 10:00 a.m. Here the party will take special busses for a two-day tour of Rocky Mountain National Park.

Sunday, July 2

Arrive Salt Lake City, 7:35 a.m. A one-day stop will be made with a complete lecture tour, featuring the many historic and romantic points of interest in the city, including the Wasatch Drive, two near-by canyons, and a portion of the old Mormon Trail. Renowned organ recital at noon in the Mormon Tabernacle. Afternoon trip to Bingham Copper Mines largest open-cut copper mine in the world with drive through Salt Lake Valley, Bingham Canyon, and stop at Saltair Beach, the famous resort on Great Salt Lake. Leave at midnight.

Monday, July 3

Arrive Lund, Utah, 7:00 a.m. Two-day tour of Cedar Breaks and Zion National Park.

Tuesday, July 4

Arrive Las Vegas, 9:00 p.m.

Wednesday, July 5

Leave Hotel at Las Vegas after breakfast for motor trip to Boulder Dam, and boat ride on Lake Mead.

Thursday, July 6

Arrive Los Angeles, 8:30 a.m. Headquarters at Biltmore Hotel. Motor drive through city and to Hollywood, Beverly Hills, and Santa Monica.

Friday, July 7

Trip to Pasadena with stops at alligator and ostrich farms. Special stop at California Institute of Technology to inspect 200-in. telescope now being ground which will be placed when finished on top of Mount Palomar, San Diego County. A trip to the new observatory on the Mount may be arranged. Motor trip through beautiful West Adams residential district, and the campus of the University of Southern California. Olympic swimming stadium, Culver City, and many moving-picture studios, will be seen on drive with special stop to inspect Warner Brothers First National Studio.

Saturday, July 8

Arrive Fresno and leave after breakfast for two-day tour of Yosemite Valley.

Monday, July 10

Arrive San Francisco where party is transferred to Fairmont Hotel, headquarters for the A.S.M.E. Semi-Annual Meeting, July 10 to July 14.

Friday, July 14

Leave Oakland, 5:30 p.m.

Saturday, July 15

Arrive Portland, the Rose City, 3:45 p.m., where the group will leave on motor trip to inspect Bonneville Dam.

Sunday, July 16

Arrive Seattle, 7:30 a.m. Complete tour of the city is planned, covering about sixty miles.

Monday, July 17

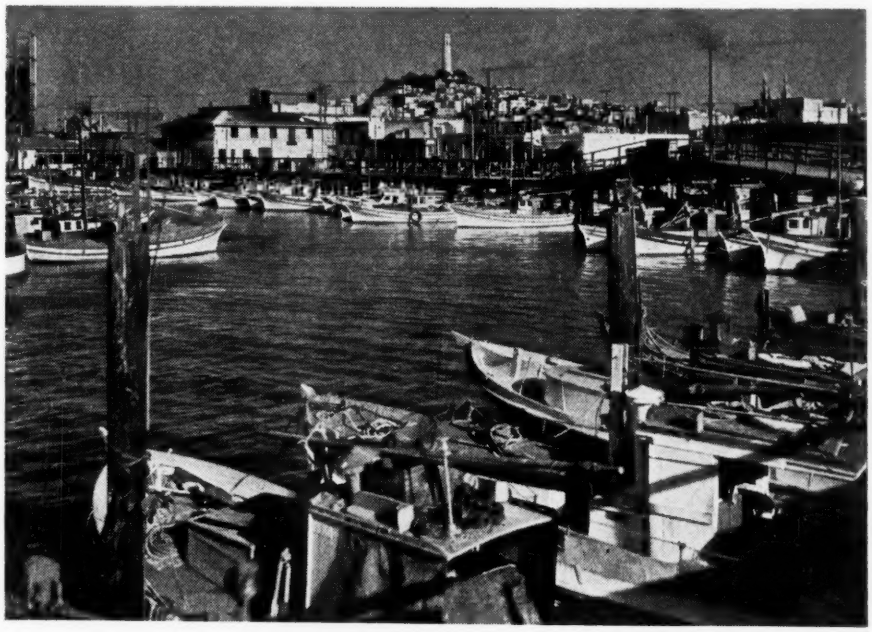
Leave Seattle 9:00 a.m. to board steamer for Victoria and Vancouver. At Victoria special stop will be made for a trip in motor-busses. Arrive Vancouver 5:55 p.m. Pullmans are boarded at 7:00 p.m. to travel through the Canadian Rockies.

Tuesday, July 18

Arrive Field, 2:00 p.m. Start of three-day colorful motor trip in the Canadian Mountains. Visits to Emerald Lake, Yoko Valley, Kicking Horse Pass, The Great Divide, and Lake Louise where stop will be made for night. The trip the next day will take the group to Banff Springs where stop will be made for night.

Thursday, July 20

Motor trip to Buffalo Park



THE FAMOUS FISHERMAN'S WHARF IN SAN FRANCISCO WITH THE FISHING FLEET BOATS IN HARBOR. COIT TOWER ON TELEGRAPH HILL IN BACKGROUND

Friday, July 21

En route

Saturday, July 22

Arrive Minneapolis, 7:00 a.m.

Sunday, July 23

Arrive Pittsburgh, 8:10 a.m., Washington, 4:55 p.m., North Philadelphia, 3:44 p.m., and New York, 5:20 p.m.

Optional Side Trip to Alaska

Because of the heavy travel expected this summer those interested in the Alaska Trip must notify the Secretary's office of the A.S.M.E. *not later than* May 15 of their interest in this trip as reservations will not be held after that date. This is *important* to note and to act upon.

Monday, July 17

Leave Vancouver 9:00 p.m. Stateroom accommodations with two persons to a room. Meals for round trip on steamer, which makes several stops en route with one to four hours layover at various ports.

Tuesday, July 18

Arrive Powell River morning
Arrive Ocean Falls evening

Wednesday, July 19

Arrive Prince Rupert, 10:00 a.m.
Arrive Ketchikan, 7:00 p.m.

Thursday, July 20

Arrive Taku Glacier, 4:00 p.m.
Arrive Juneau, 7:00 p.m.

Friday, July 21

Arrive Skagway, 9:00 a.m. Train leaves dock shortly after arrival for Carcross at north end of Lake Bennett which is reached about noon where steamer is boarded for trip down beautiful Lake Tagish. Arrive back at Carcross next morning in time to entrain for Skagway arriving there that afternoon with ample time to see the town.

Saturday, July 22

Leave Skagway, 6:00 p.m.

Sunday, July 23

Leave Juneau, 1:30 a.m.
Arrive Wrangell, 2:00 p.m.

Monday, July 24

Arrive Prince Rupert, 9:00 a.m.

Tuesday, July 25

En route through Canadian Rockies

Wednesday, July 26

Arrive Jasper where two and one-half day stop will be made in the heart of the Canadian Rockies. All day to enjoy golf, tennis, boating, swimming, hiking, and horseback riding.

Thursday, July 27

All-day trip (150 miles) to Columbia Icefield and return.

Saturday, July 29

En route through wheat fields of Saskatchewan and Manitoba.

Sunday, July 30

Arrive St. Paul, 8:00 a.m.

Monday, July 31

Arrive New York, 9:30 a.m.

A.S.M.E. Oil and Gas Power Division to Hold National Meeting at Ann Arbor in June

Fourteen Papers of Vital Interest to Diesel Industry Scheduled for Presentation

THIS YEAR the Oil and Gas Power Division of the A.S.M.E. is to hold its national meeting at the University of Michigan, Ann Arbor, Mich., June 19 to 22.

The program covers five sessions at which papers will be presented and one afternoon session which will be given over to inspection trips or entertainment. Fourteen papers are scheduled and in addition an oral discussion on the development of General Motors Diesels and their future. F. G. Shoemaker of the General Motors Detroit Division will give this talk before the inspection of the company's Diesel plant.

All of the papers to be presented are on subjects of vital interest to the Diesel industry and the authors have been selected because of their leadership in this field.

An even larger than usual attendance is expected. The University of Michigan is particularly well prepared to handle a meeting of this kind and all who attend are assured of worth-while sessions.

The program follows:

Program

Monday, June 19

2:00 p.m.

Oil- and Gas-Engine Practice in Great Britain, by A. K. Bruce, London, England

Résumé of European Design of Internal-Combustion Engines, by M. Bochet, Paris, France

High-Speed Diesel Engine Development in U. S., by C. G. A. Rosen, Caterpillar Tractor Company

Tuesday, June 20

9 a.m.

Joint Use of Diesel Engines and Utility Power, by Edgar J. Kates, New York, N. Y.

Where Does Interpretation Begin?—Analysis of Oil-Engine Power Cost Report, by P. H. Schweitzer, The Pennsylvania State College

2:00 p.m.

Symposium on Piston-Ring Troubles: Introductory remarks and discussion led by H. L. Kohler, University of Michigan

(1) Factors Affecting Design and Materials, by J. M. Dodge, Double Seal Ring Company

(2) Wear of Diesel-Engine Cylinders and Rings, by Paul S. Lane, American Hammered Piston-Ring Company

(3) Practical Service Conditions, by D. D. Cook, Cooktite Ring Sales Company

(4) Rings From Users Standpoint, by Stuart Nixon, Sealed Power Corporation

Wednesday, June 21

9:00 a.m.

Stability of Crank Case Oils, by Walter F. Weiland, University of Nebraska

Operation of Lubricating Oil Systems, by Paul Williams, Skinner Purifiers, Inc.

Discussion: Development of G. M. Two-Cycle, High-Speed Diesels and Their Future, led by F. G. Shoemaker, General Motors Diesel Division

Afternoon

Trip to plant of General Motors Diesel Division

Trip through Greenfield Village

Entertainment as arranged by Univ. of Michigan

8:00 p.m.

Banquet

Entertainment

Speakers to be arranged. Talk will be given on "War Department: Diesels for National Defense," or there will be moving pictures with talk concerning "Diesels in Railroad Service."

Thursday, June 22

9:00 a.m.

Interpretation of Smoky Exhaust of Diesel Engines, by H. E. Degler, University of Texas

Characteristics and Development of Combustion Chambers of American High-Speed Compression-Ignition Oil Engines, by V. L. Maleev, Oklahoma Agriculture & Mechanical College

Injection Systems for Oil Engines, by E. T. Vincent, University of Michigan.

A.S.M.E. Calendar

of Coming Meetings

June 14–15, 1939
Applied Mechanics Division
New York, N. Y.

June 19–22, 1939
Oil and Gas Power Division
Ann Arbor, Mich.

July 10–15, 1939
Semi-Annual Meeting
San Francisco, Calif.

September 4–8, 1939
Fall Meeting
New York, N. Y.

October 5–7, 1939
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Columbus, Ohio

October 5, 1939
Machine Shop Practice Division to hold "A.S.M.E. Day" at Machine Tool Congress, Cleveland, Ohio

October, 1939
Wood Industries Division
Boston, Mass.

December 4–8, 1939
Annual Meeting
New York, N. Y.-Philadelphia Pa.

Engineers' Day at Southern Textile Exposition, Greenville, S. C., April 5, 1939

THE A.S.M.E. Textile Division of the Society held a most interesting meeting at the Poinsett Hotel, Greenville, S. C., Wednesday, April 5, 1939, with a technical session in the morning at which the following papers were presented:

The Future of Lighter-Than-Air Craft, by F. C. Mills, member Student Branch A.S.M.E., and student of mechanical engineering at Clemson Agricultural College.

New Mechanical Ideas and the Textile Engineer, by Frank U. Naughton, Jr., of Hyatt Bearings Division of General Motors Corporation, Worcester, Mass.

The Fluorescent Lamp, Its Development and Application, by G. E. Park of General Electric Co., Charlotte, N. C.

Flax, Its Possibilities for the Cotton Textile Industry, by C. G. Worthington, Research Fellow, Georgia School of Technology, Atlanta, Ga.

Governor Maybank Attends Banquet

The afternoon was devoted to a visit to the Southern Textile Exposition and culminated with a banquet in the evening which was attended by the Governor of South Carolina, Burnet R. Maybank, the Mayor of Greenville, C. F. McCullough, a distinguished delegation of state officials, members of the A.S.M.E., the Chamber of Commerce, and county delegates. The Governor spoke briefly pledging his continued cooperation with all industries, present and prospective. At the banquet was presented a burlesque joint session of the general assembly with Speaker Sol Blatt solemnly presiding as several satirical resolutions were introduced and passed by an overwhelming vote.

J. D. Robertson Extends Society Greetings

Chairman of the Textile Division, J. D. Robertson, opened the meeting and extended greetings on behalf of the A.S.M.E. to the 200 guests. He pointed out the opportunity for mechanical engineers connected with the textile industry to join in the Society's work and stated that most textile production operations are mechanical ones, and that therefore the Society's program of papers and meetings are to be directed toward working out the problem of producing a better product at a lower cost. He then introduced Eugene W. O'Brien

of Atlanta, past vice-president of the Society, who acted as toastmaster.

Prominent Visitors

Prominent visitors in the engineering field included Deans Sam B. Earle and H. H. Willis of Clemson College School of Engineering; and Frederick M. Feiker, executive secretary of the American Engineering Council. J. E. Sirrine, prominent Greenville engineer, addressed the group briefly outlining the history of the textile industry in the state and requesting that the state government cooperate in promoting its interest. H. H. Iler, chairman of the A.S.M.E. Greenville Section and J. H. Sams, secretary, made the local arrangements and extended the cordial hospitality for which the South is noted.

The next A.S.M.E. meeting at which textile subjects will be discussed is at a session of the 1939 Annual Meeting of the Society to be held in December at Philadelphia.

Economics Conference for Engineers, June 24–July 3

THE INTERRELATIONS of business and government will constitute the general theme of the ninth annual Economics Conference for Engineers at the Stevens engineering camp, Johnsonburg, N. J., June 24 to July 3, 1939. This year the conference is being sponsored jointly by Stevens Institute of Technology, the Management Division of The American Society of Mechanical Engineers, and the New York section of the American Institute of Mining and Metallurgical Engineers.

The conference will be addressed at the first session, on Saturday evening, June 24, by Dr. Leverett S. Lyon, executive vice-president, Brookings Institution of Washington, on "Business and Government: An Orientation View." Speakers at evening sessions during the succeeding week will include, Virgil Jordan, president, National Industrial Conference Board, on "Enterprise Vs. Authority as Principles of Economic and Social Progress," by Carroll Miller, commissioner, Interstate Commerce Commission, on "Government and the Business of Transportation," by R. V. Fletcher, vice-president and general counsel, Association of American Railroads, on "A Program for Railroad Recovery," by J. G. Lyne on "Labor Relations—The Railroads' No. 1 Problem," by Thurlow M. Gordon on "The Current Approach to the Monopoly Problem," and by Prof. Walter E. Spahr, New York University, on "Recent Monetary Problems."

Coordinated lectures and discussions, with nine morning sessions of the conference devoted to each topic, will deal with the United States patent system, labor and wages, taxation for business control, industrial psychology, job evaluation and merit rating, and cost analysis and control. Each member of the conference group may elect to attend two of the six sessions held each morning. A complete day-by-day program of the 1939 Economics Conference may be obtained from the President's Office, Stevens Institute of Technology, Hoboken, N. J.

LOW MEMORIAL LIBRARY AT COLUMBIA UNIVERSITY

Applied Mechanics Division of A.S.M.E. Announces Its Program for National Meeting in June

Columbia University to Be Host to Division June 14–15 Thirteen Papers in Four Sessions

AT THE invitation of Columbia University in New York the Applied Mechanics Division of the A.S.M.E. is to hold its national 1939 meeting there on June 14 and 15. Plans are being made to provide living accommodations in the dormitories of the University, details of which will be announced later. A visit to and dinner at the World's Fair is also in prospect.

The program for the meeting has been completed and the four sessions on elasticity, elasticity and plasticity, lubrication, and dynamics with their papers follow:

Elasticity

S. Timoshenko, *Chairman*

Clamped Rectangular Plate With a Central Concentrated Load, by Dana Young

A Theory of Flexure for Beams With Nonparallel Extreme Fibers, by Wm. R. Osgood

Analysis of Spherical Shells of Variable Wall Thickness, by M. E. Spotts

The Spring Clutch, by C. F. Wiebusch

Elasticity and Plasticity

A. Nádai, *Chairman*

Creep, Elastic Hysteresis, and Damping in Bakelite, by Herbert Leaderman

Chain Links Under Cross Forces, by Jos. B. Reynolds

Calculation of Stresses Within the Boundary of Photoelastic Models, by R. Weller and G. H. Shortley

Lubrication

G. B. Karelitz, *Chairman*

The Thick-Film Lubrication of Journal Bearings of Finite Length, by M. Muskat and F. Morgan

Boundary Friction in Bearings at Low Loads, by L. M. Tichvinsky and E. G., Fischer

Theoretical Pressure Distribution in Journal Bearings, by E. O. Waters

Dynamics

J. Ormondroyd, *Chairman*

Rubber Springs in Shear Loading, by J. F. D. Smith

The Application of Normal Coordinates Toward Torsional-Oscillation Calculations of Turbine Propulsion Equipment, by H. Poritsky and C. S. L. Robinson

Vibration of Locomotive Driving Wheels Caused by Unbalance, by O. J. Horger and C. W. Nelson

A.S.M.E. Local Sections Are Joint Sponsors With Others of Meetings and Conferences

Included Are Management Conference, Wisconsin Engineering Conference, Textile Meeting, and Midwest Power Conference

TRI-CITIES, Milwaukee, Rock River Valley, Greenville, and Chicago Sections of the A.S.M.E. helped to broaden the usefulness of the engineering profession by sponsoring severally and in cooperation with other engineering and technical societies several joint meetings and conferences during the months of March and April. Especially noteworthy was the fact that many of the papers were presented by A.S.M.E. members.

Management Conference

The 1939 Management Conference at Iowa City, Iowa, March 31, was sponsored by the Tri-Cities Section, the college of engineering of the University of Iowa, the Iowa Manufacturers Association, and the Society for the Advancement of Management. At the time-and-motion-study session in the morning, Ralph M. Barnes, member A.S.M.E., discussed "Recent Developments in Motion-Study Research." Chairman of the afternoon session on "Styling of Products" was R. A. Cross, vice-chairman of the Tri-Cities Section. The informal dinner in the evening had as toastmaster, Huber O. Croft, member A.S.M.E., and head of the department of mechanical engineering at the University. The committee on arrangements included Professor Barnes, chairman, and Charles A. Carlson, secretary-treasurer, Tri-Cities Section.

Wisconsin Engineering Conference

Milwaukee, Wis., was the scene from March 15 to 17 of the 1939 Wisconsin Engineering Conference which was sponsored by the Engineering Society of Wisconsin in cooperation with the Milwaukee and Rock River Valley Sections of the A.S.M.E., and other technical groups. According to Walther C. von Fischer, secretary-treasurer of the Rock River Valley Section, some of the most successful sessions were those arranged by the A.S.M.E. These and other sessions during the three-day meeting included papers by Hans Dahlstrand, member A.S.M.E., on "Problems of Steam-Turbine Design," by M. K. Drewry, member A.S.M.E., on "Engineering Principles Guide Power Generation Progress," by L. W. Wallace, vice-president A.S.M.E., on "Developments in Air Conditioning," by D. W. Nelson, member A.S.M.E., on "Introduction and Diffusion of Conditioned Air in Rooms," and by G. L. Tuve, member A.S.M.E., on "Research Gives Some Unexpected Results." Cochairmen of the mechanical-engineering sessions were R. C. Glazebrook and Ray C. Newhouse, members A.S.M.E.

Textile Meeting

As part of the thirteenth Southern Textile Exposition in Greenville, S. C., April 3–8, a joint meeting of the Textile Division and the Greenville Section of the A.S.M.E. was held on Wednesday, April 5. At the technical session in the morning, F. C. Mills, student member A.S.M.E., discussed "The Future of Lighter-Than-Air Craft," Frank U. Naughton, Junior A.S.M.E., described "New Mechanical Ideas and the Textile Engineer," and C. G. Worthington, member A.S.M.E., talked on "Flax, Its Possibilities for the Cotton Textile Industry." At the dinner in the evening, J. D. Robertson, chairman of the Textile Division, A.S.M.E., presided and E. W. O'Brien, past vice-president A.S.M.E., acted as toastmaster. Addresses at the dinner were delivered by J. E. Sirrine, member A.S.M.E., and Burnet R. Maybank, Governor of South Carolina. A more detailed report of this meeting appears on page 410.

Midwest Power Conference

The Midwest Power Conference, sponsored by Armour Institute of Technology with the cooperation of the Chicago Section, A.S.M.E., and other educational and technical organizations, was held in Chicago, April 5–7. Much of the success of the conference was due to the many A.S.M.E. members who presented papers on various phases of power generation. The two main papers of the meeting were presented by A.S.M.E. members: "The Achievements of Research in Power," by L. W. Wallace, vice-president of the Society, and "Developments in Central-Station Power Plants," by Alex D. Bailey, past vice-president of the Society. Other A.S.M.E. members who were speakers included F. D. Elwell, G. A. Gaffert, J. J. Kanter, L. H. Morrison, C. G. A. Rosen, R. V. Kleinschmidt, G. C. Daniels, Arthur L. Rice, and R. V. Terry.

News of Local Sections

Polarized Light Discussed at Anthracite–Lehigh Valley

HOLDING its regular meeting in Pottsville, Pa., on Mar. 24, the Anthracite–Lehigh Valley Section presented a talk on "Polarized Light" by Dr. Paul M. Kendig. He reviewed the historical development of wave motions in order to lead up to an understanding of polarized light, which was explained with the aid of slides, diagrams, and demonstrations.

SPEAKERS AND CHAIRMAN OF MANAGEMENT CONFERENCE AT IOWA CITY, MARCH 31

(Standing left to right: L. S. Whitson, Harold Van Doren, R. A. Cross, Marvin E. Mundel, H. O. Croft, E. F. Boyle, Ira Maxon, L. A. Flagler, R. G. Wright, and Ralph M. Barnes. Seated left to right: F. M. Dawson and Henry L. Nunn. Mr. Nunn was the speaker at the banquet on the topic "The Stabilization of Employment—Modern Management's Greatest Challenge.")

Atlanta Has Speakers From Providence and New York

Atlanta Section had J. H. Williams, member A.S.M.E., of Providence, R. I., as guest speaker on Mar. 20, and Geo. A. Orrok, honorary member A.S.M.E., of New York, on Mar. 24. Mr. Williams' subject was "Welding of Piping to Meet A.S.A. Code Standards" in which he made a prediction that steam at 1050 F and a pressure of 2500 psi would be in use five years from now. That this is possible was made evident by the talk by Mr. Orrok in which he discussed the development of modern high-pressure turbines in various countries of the world. Of particular interest was Mr. Orrok's comparison of steam and Diesel, and steam- and hydropower costs.

Boston Section Presents South American Side Show

The noted South American commercial explorer, naturalist, and author, William LaVarre, was the speaker at the April 5 meeting of the Boston Section. He gave an interesting talk on commercial exploration

in the tropical jungles of South America and showed colored lantern slides of many interesting scenes.

Bridgeport Has Test Pilot for Speaker at March Meeting

Alfred Marshall, test pilot for United Aircraft Corp., was the guest speaker on March 23 at a regular meeting of the Bridgeport Section. More than 300 members and guests heard him tell of his various experiences with modern airplanes and saw a motion picture of the construction of Lockheed, Douglas, and other makes of aircraft.

Central Illinois Meeting Features Portland Cement

Bert H. Puerner, consulting engineer, who has been engaged in the design, construction, and operation of stone-crushing and cement machinery in the United States, Japan, China, and Russia, gave a talk on the "Processing of Portland Cement" before the members of the Central Illinois Section on March 16. He explained the mechanical and chemical factors which enter into cement manufacture and showed slides to illustrate his talk. A motion picture of life in Russia, taken by the speaker while in that country in 1930, added to the entertainment of the evening.

Central Indiana Offers Prize of $10 to Students

The Central Indiana Section is offering $10 in cash to the senior student member of the Purdue Branch who gives the best five-minute talk on "The Kind of a Boss I'd Like to Have."

Charlotte Section Welcomes C. E. Davies

C. E. Davies, Secretary of the A.S.M.E., was the guest of honor at a dinner meeting of the Charlotte Section on March 13. In his address following the dinner he discussed the E.C.P.D.

Statistics in Industry at Chicago Meeting

Application of statistics to industry was the subject of a meeting of the Chicago Section, March 10. The one-day session was directed by H. F. Dodge. Speakers and their subjects were as follows: W. S. Ettinger, "The Control of Quality in Industry;" Dr. E. S. Grummell, of London, England, "Statistical Methods in Industry;" Dr. D. R. G. Cowan, "Developing and Improving Products by Consumer Testing;" and C. S. Barrett, "An Application of Sampling in Quality Control of Manufactured Goods."

Cleveland Discusses High-Speed Traffic Arteries for the City

The problem of providing adequate highways to accommodate increased traffic in the Cleveland area was discussed at a meeting of the Cleveland Section on March 6 by A. S. Porter, chief deputy county engineer for Cuyahoga County. He traced the methods used to plan and construct roads and highways. According to Mr. Porter, the engineering details involved in the construction of any highway project are often secondary to obtaining the right-of-way and selling the need and value of the project to those who must pay for it, namely, the public.

Ithaca Opposes Amendment to N. Y. Licensing Law

At the meeting of March 3, members of the Ithaca Section received copies of the proposed amendment to the New York State Engineering License Law which would require future engineers to finish a preengineering course of two years before being admitted to an engineering school. After much discussion, the Section went on record as opposing the amendment and sent copies of the resolution to the legislature and its committee on education.

Alfred Iddles Speaks Before Kansas City Section

Alfred Iddles, vice-president of the Society, delivered a paper on boiler and furnace design before the Kansas City Section on March 24. The talk was illustrated with slides and colored motion pictures, which showed actual combustion in boiler furnaces. A lively discussion followed.

C. E. Davies at Knoxville

On his trip through the South following the Spring Meeting of the A.S.M.E. in New Orleans, C. E. Davies, Secretary of the Society, stopped off at Knoxville on March 10 to meet the members of the Atlanta Section. More than 40 turned out to fete him at a dinner and hear him talk on "Building a Profession."

Louisville Members Learn About Welding of Pipes

An illustrated lecture on "High-Pressure, High-Temperature Piping" was presented before the members of the Louisville Section on March 21 by D. H. Corey, member A.S.M.E. His talk covered types of joints, chamfering, weld rings, joints made in the field, reinforcement, preheating, annealing, welding tests, and X ray of joints. A lively discussion followed the talk.

Metropolitan Section Has Record Turnout for Meetings

More than 300 members, guests, and ladies were present on March 9 at a meeting of the Transportation and Hydraulic Groups of the Metropolitan Section at which R. B. Renner, past chairman of the Materials Handling Division, gave a talk and showed motion pictures on the "Grand Coulee Dam." He explained the material-handling methods and equipment used in the construction of the dam. The meeting was in charge of E. J. Wiseman and the chairman of the session, F. M. Gibson, was introduced by Harold Carlson.

Hundreds of members and guests attended the March 23 meeting of the Machine Shop Practice Group of the Metropolitan Section to hear D. A. Wallace, president of the Chrysler Division of Chrysler Corporation, talk on "Superfinish," a new process of finishing metal surfaces to a smoothness on which there are no scratches of any sort more than a few millionths of an inch in depth.

North Texas Section Sponsors Special Student Meeting

In order to select the best paper for submission at the Southwest Student Meeting, Southern Methodist Student Branch and the North Texas Section held a joint meeting on March 9 at which five student papers were presented. John D. Wisenbamer won with a paper on "Pressure Maintenance in Oil Fields Through Recycling."

Mathematics of Management Discussed at Ontario

Meeting at the University of Toronto on March 9, members of Ontario Section listened to an address on the "Mathematics of Management" by Paul Kellogg. He discussed fundamental costs relative to the operation of any business, illustrating his talk by a simple formula which could be used to solve the everyday problems of modern business.

On March 14, more than 100 members and guests welcomed A. G. Christie, President of the Society. His paper on "Modern Steam Generators" was well received.

300 at Philadelphia Meeting Breaks 3-Year Record

When more than 300 members and guests attended the March 28 meeting of the Philadelphia Section to take part in a discussion on "Welding in Power Equipment and Plant," a three-year old attendance record was broken. The subject of the evening was introduced by N. L. Mochel and Dr. A. E. White, and the discussion was led by J. McKee, M. Christensen, and A. J. Moses.

Section Member Talks Before Rock River Valley Section

Prof. Ben G. Elliott, member A.S.M.E., told the members on March 23 at a meeting in Beloit, Wis., about "What's Happening in Engineering Education." The discussion which followed the talk demonstrated more than anything else the value of the paper in making the audience think about this subject.

Control of Fly Ash Urged by Dutch Engineer in St. Louis

Control of fly ash at power-plant stacks is required by considerations of public interest and community economics as well as public health, Herman Van Tongeren, of Heemstede,

Holland, inventor of fly-ash and dust collector systems and consulting engineer to many European industries, said on March 31 in a talk which he gave before the St. Louis Section. The talk was illustrated with motion pictures.

Television at Schenectady

At the meeting on March 9 of the Schenectady Section, C. A. Priest, engineer, General Electric Company, discussed the principles of operation and details of construction of the new television transmitter soon to be put into operation near Schenectady. He also reviewed the progress of television to date, considering different methods of transmission, difficulties which have been overcome, and standards set up to insure uniformity of equipment and transmission methods.

Lubrication and Oil Well Meetings at South Texas

On March 17, J. C. Dittbrener, of Magnolia Petroleum Co., discussed before the Junior Group of the South Texas Section, meeting in Houston, Texas, the topic of "Industrial Lubrication." At the March 30 meeting, Herbert Allen, member A.S.M.E., and chief engineer, Cameron Iron Works, described the "Design of Control Equipment for High-Pressure Oil and Gas Wells."

Utah Members Hear About Giant Water Project

Meeting in Salt Lake City on Feb. 28, members of the Utah Section heard Leland H. Kimball, engineer for the Metropolitan Water District and first vice-president of the Engineers Committee for the Utilization of the Colorado River in Utah, describe a project which would divert one and one-half million acre-feet of water from the Green River, and elevate it to flow into the Great Basin to provide irrigation, industrial and municipal water, either directly or by exchange.

Western Washington Sponsors Annual Engineering Meeting

About 150 members of the Western Washington Section of the A.S.M.E. and of the local groups of the A.I.M.E., A.S.C.E., and A.I.E.E. attended the 14th annual Joint Meeting of the Four Founder Societies in Seattle on March 17. Guest speakers were H. I. Neer, who spoke on "Modern Plastics—Principles and Practices," and W. W. Offner, who talked on "X-Ray Examination of Castings and Welds."

Rain Fails to Stop Waterbury

Despite the heavy rainfall on the evening of March 15, 45 members and guests of the Waterbury Section gathered at the American Brass Association Hall to hear Henry T. Wayne, industrial sales engineer, Bausch & Lomb Optical Co., give a brief outline of the founding of his company, touching on the development of various optical instruments, and explain the uses of the countour measuring projector.

C. E. Davies at Worcester

C. E. Davies was the guest of honor of the Worcester Section on March 21. After his instructive talk on the E.C.P.D. the following student members of the A.S.M.E. from Worcester Polytechnic Institute presented papers: Donald Houser, Ronald Brand, and David Hunt.

Detroit Section to Meet With Students, May 16

On Tuesday, May 16, the Detroit Section will hold its annual Student Branch Meeting for the entertainment of student members from the Universities of Michigan and Detroit, and from Michigan State College. At 2 p.m., D. A. Wallace, president of the Chrysler Division, will talk on "Superfinish." After an inspection of the Chrysler Jefferson plant, the student members will be guests of the company at a dinner served in the plant cafeteria. Following the dinner, members will hear a talk on "New Frontiers" by Dr. Thomas, president of the Chrysler Engineering Institute.

Cleveland Section Goes Back to College

More than 100 members of the Cleveland Section had an instructive evening on April 5 at a "Back-to-College" meeting as guests of the Student Branch of the Case School of Applied Science. After having a sumptuous meal in one of the drafting rooms, the audience saw a motion picture, "Hurricane's Challenge," which showed the havoc wrought by the hurricane which swept New England. Then, senior mechanical-engineering students demonstrated various experimental setups used by them to gather data for their theses which must be based on some subject of original research.

Junior Group Activities

35 at Kansas City Meeting

THE REGULAR meeting of the Junior Group of the Kansas City Section was held on March 14 at the Kansas City Light & Power Company building. Roy Hahn, chairman, introduced aviation-cadet W. Nixon, who presented two sound motion pictures, one on naval battle maneuvers and the other on the course of the naval air cadet at Pensacola, Fla. Following this, Harold Manuel spoke on "Tire Treads."

Frisco Juniors Settle Labor Problem

SAN FRANCISCO Juniors held their eighth group seminar on March 9. E. C. Floyd presided and the topic of the evening was "Labor Problems and Industry." Marion Hughes, the first speaker, said that there were 130,000,000 factors influencing labor problems, with the three main ones, in his estimation, being consideration of methods and materials, concentration of men, and fear. Bert Hirsch contributed the fact that in a recent survey it was shown that most discharges were due to the fault of the employees themselves. He then mentioned the various efforts being made by employers to better the conditions of the workers, such as safety-first programs, better working hours and conditions, and fair wages.

Philadelphia Juniors in Brewery

PHILADELPHIA Junior Group members made an inspection trip to the C. Schmidt & Son Brewery on March 18. Everyone had a good time. At the March 8 meeting, J. D. Peterson, Socony-Vacuum Oil Co., explained the process of making gasoline from crude oil, and Elmer Griscom, Sinclair Refining Co., described the resultant product.

E.C.P.D. Explained to Metro Juniors

METROPOLITAN Juniors saw the "1938 Annual Meeting" motion pictures, and heard an enlightening talk on "The Engineers' Council for Professional Development" at the March 21 meeting of the group. O. B. Schier, 2nd, secretary of the A.S.M.E. Metropolitan Section, explained the aims and progress of the E.C.P.D. and pointed out the various means by which this important organization carries on the work of enhancing the professional status of the Engineer.

Mr. Schier pointed out that E.C.P.D. begins its work with juniors in high schools, through the medium of such advisory conferences and camps as are jointly sponsored with Lafayette College and Stevens Institute of Technology, as well as by having councilors visit secondary and prep schools. The purpose of all this is to inform prospective engineering students as to just what is meant by engineering as a profession, in order to improve the standard of students entering U. S. technical institutions.

The development program involving recognition of engineering schools on the basis of compliance with certain minimum educational standards was also explained by Mr. Schier. He pointed out that such recognition will probably be necessary before credit will be given for undergraduate study period by the review boards under professional licensing laws of various states.

With the Student Branches

6000 Student Members of A.S.M.E. Represented at Ten Group Meetings

A.S.M.E., Old Guard, and Many Special Prizes Create Intensive Competition Among Students

TEN Student Group Meetings of the Student Branches of the A.S.M.E. have been held or are still being conducted throughout the nation. With almost 6000 student members enrolled in 117 Student Branches in the United States and Canada, a year of intense activity is being concluded with these regional meetings, at each of which more than $100 in A.S.M.E., Old Guard, and special prizes are awarded to student members for the best papers presented.

Southwest Group Meeting

With Southern Methodist Branch as host, the fifth annual Southwest Student Group Meeting took place in Dallas, Texas, March 19–21. First prize of $45 went to Rudolph Bodemuller, Texas Branch, for his paper on "Smoke Density—A Combustion-Quality Indicator." Other prizes and winners were $25 to M. C. Green, Texas Tech Branch; $15 to John D. Wisenbaker, Southern Methodist Branch; Old Guard prize of $10 to Kenneth W. McLoad, Arkansas Branch; log-log duplex slide rule to L. J. Powers, Texas Tech Branch; North Texas Section prize of $5 to R. B. Kilgore, Southern Methodist Branch. Honorable mention was given to John C. Martin, Texas A.&M. Branch; John C. Martin, Rice Branch; G. W. Staples, Texas A.&M. Branch; and R. A. Watson, Rice Branch.

Pacific Northwest Group Meeting

At the Pacific Northwest Student Group Meeting in Corvallis, Oregon, April 2–4, Oregon State College Branch acted as host. First prize was given to J. F. Crews, Oregon State Branch, for his paper on "Heat Transfer to Boiling Refrigerants." Second prize was won by Paul Sherwood, Washington Branch; third prize by Edward H. Moore, Oregon State Branch; and the Old Guard prize by Arthur Kraus, Washington State Branch.

Pacific Southwest Group Meeting

The University of Nevada was host for the Pacific Southwest Student Group Meeting in San Francisco, Calif., April 3–4. There were two first prizes—one to Albert R. Champion, University of California Branch, for his paper "Discussion of Aviation," and the other to Melvin Tilley, University of Nevada Branch, whose paper was entitled "Reclaiming Lubricating Oil From Air and Ammonia Compressors." There was no second prize. Third prize went to Walter Nass, Southern California Branch, for his paper on "Electrical Timing for Racing Cars," and the fourth to Jack S. Parker, Stanford Branch, for his paper "A New Method of Boring Mine Shafts." The Old Guard Prize was awarded William P. LeDuc, Southern California Branch, for his paper "Application of Accoustical Control."

North Central Student Group Meeting Date Changed to May 5–6

THE DATE of the North Central Student Group Meeting, scheduled for St. Louis, Mo., April 20–21, with Missouri School of Mines and Metallurgy as host, has been changed to May 5–6. According to Prof. A. J. Miles, honorary chairman of the host Branch, this was done to accommodate students and faculties of the attending schools and prevent conflicts with other activities.

STUDENT MEMBERS OF THE UNIVERSITY OF BRITISH COLUMBIA STUDENT BRANCH, VANCOUVER, B. C.

Here and There

New Courses at Brooklyn Poly

NEW curricula leading to the degrees of bachelor of metallurgical engineering and bachelor of aeronautical engineering, respectively, have been added to the program of the Polytechnic Institute of Brooklyn according to a report from the Brooklyn Poly Branch. Although many of the subjects embraced in the new curricula have been offered for years, either as required or elective prerequisites to the mechanical-engineering degree, the growing demand for students specially trained in both metallurgy and aeronautics has been responsible for the inauguration of the new degree curricula.

At the meeting of March 10 of the Armour Branch, it was announced that inspection trips had been planned to the Crane Co. on March 15, and to the Carnegie Steel Mills, the first week in April. R. Fridstien gave a 20-minute talk on "Modern Stokers."

Bucknell Branch members made a trip through the Lewisburg Chair Co. One of the main attractions was an old Corliss steam engine which is still giving good service.

California Honors St. Patrick

On March 17, California Branch members in cooperation with other technical groups

AT THE SEVENTH PACIFIC NORTHWEST GROUP MEETING OF A.S.M.E. STUDENT BRANCHES, CORVALLIS, ORE., APRIL 2–4

COOPER UNION BRANCH MEMBERS TURN OUT FOR A GROUP PICTURE

held the annual Barn Dance in honor of St. Patrick, the patron saint of mechanical engineers. At the March 2 meeting, Professor Boelter spoke on job possibilities for graduates, Professor Folsom advised the junior students on planning their courses for next semester, and Mr. Hutchinson stressed the value of cultural electives. The March 14 session featured talks by the following student members: Al Champion, Fred Gabor, Emil Barrish, Eli Zeitlin, and George Hayes.

CALIFORNIA TECH BRANCH members spent a profitable two hours in visiting the Los Angeles plant of the Firestone Tire & Rubber Co. on March 3. There they saw the manufacture of tires, tubes, and friction tape from the raw rubber to finished products.

Carnegie Tech "Work-Learn" Scholarships

CARNEGIE TECH, in cooperation with the Westinghouse Electric & Manufacturing Co., has begun a search for the second group of 10 boys who will be trained as engineers under a five-year "work-learn" study program. The cooperative engineering educational plan, which enables the student to obtain practical experience in Westinghouse plants during five summer vacations and two college semesters as well as to complete eight semesters of college class work, was launched last summer with the selection of the first 10 scholarship students. Each scholarship has a value of $3000 and is awarded to a student of exceptional ability, final selection being based on results of competitive examinations, character, and personality. Applications each year must be received before April 15.

On March 9, at the invitation of CATHOLIC UNIVERSITY BRANCH, Prof. A. G. Christie, President of the A.S.M.E., gave a lecture on "Modern Steam Generators." Represented at the meeting were the MARYLAND BRANCH, GEORGE WASHINGTON BRANCH, and the Washington, D. C., Section of the A.S.M.E.

About 50 members and guests of C.C.N.Y. BRANCH saw the presentation on March 9 of several reels of films from the N.A.C.A. on the effects of the variation of air-fuel ratio and nozzle design in Diesel engines upon cylinder combustion.

Starting on Monday, April 10, members of CLARKSON BRANCH began a series of inspection trips to various plants in the central part of New York State. Some of the companies included in the itinerary were The Air-Cooled Engine Co., Carrier Co., Haberle Brewing Corp., American Locomotive Co., Gould Pump Co., Corning Glass Works, and the Ingersoll-Rand Corp. Friday morning the travelers registered at Ithaca for the New England Student Group Meeting.

COOPER UNION BRANCH at its meeting of March 15 presented talks on "The Still Engine," by Charles Caccamo, and "Splices," by Joe Black.

Cornell Has Large Turnout

CORNELL BRANCH had one of its largest turnouts on March 14 when almost 100 members and guests were present to hear a talk on "Steam Turbines," by Francis Hodgkinson, 1938 Holley Medalist of the A.S.M.E. His talk covered the design of turbine blades and the general design of a turbine.

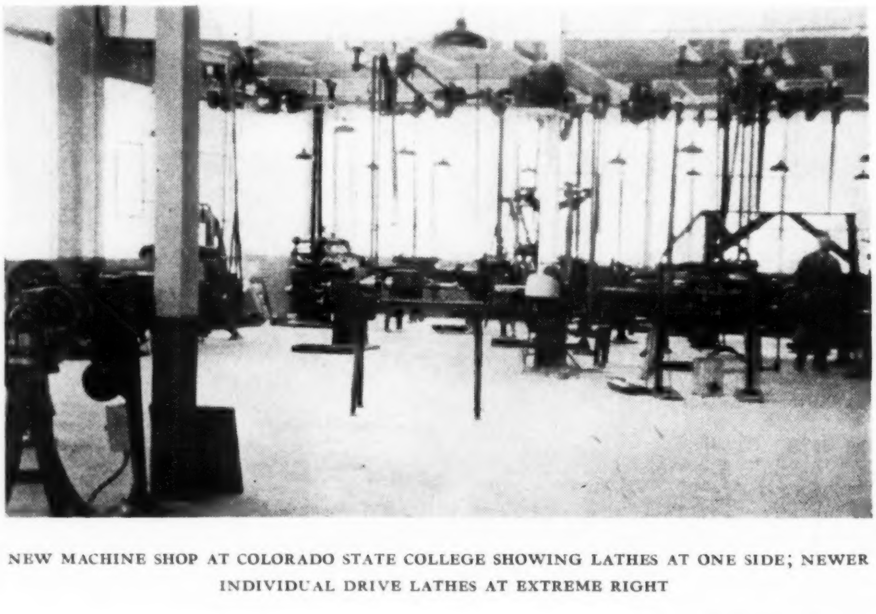
Following an established custom, the seventh annual Slide-Rule Dinner, major engineering social affair sponsored by the DETROIT BRANCH of the A.S.M.E. and other engineering organizations of the University of Detroit, took place on March 30. Chairman of the affair was Donald J. La Belle, chairman of the Branch. Guest speakers of the evening included James W. Parker, Vice-President of the A.S.M.E., who spoke on "A Profession Undefined," in which he pointed out the increasingly important role which an engineer must play as society becomes more complex. The other speaker was Tore Franzen, who discussed "Carl Johansson and His Life Work," in which he told the story of the Swedish genius who developed the gages which are used by industry throughout the world. Toastmaster for the evening was Harvey Campbell, president of the Detroit Board of Commerce, who kept the audience in "stitches."

FLORIDA BRANCH had eight members who went to the Southern Student Meeting in Knoxville, Tenn., Apr. 10–11. At the March 31 meeting of the Branch, the two speakers were C. H. Stanton and F. L. Tunis.

318 at Idaho Meeting

Through the efforts of the IDAHO BRANCH, the U. S. Steel Corporation's technicolor sound film, "Steel, Man's Servant," was shown to 318 members and guests at a local theater on Feb. 28. Glenn Harding, secretary of the Branch, reports that a leave of absence has been granted to Professor Gauss to attend the California Institute of Technology and his place as honorary chairman of the Branch has been filled for the interim by Mr. Schroeder, who is doing a good job.

ILLINOIS BRANCH has a record membership of 140 this year. In competition for the privilege of representing the Branch at the Student Meeting in Chicago, Apr. 17–18, papers were presented at the March 22 meeting by W. G. Voight, J. Gray, J. L. Slonneger, S. W. Baker, R. P. Campbell, and W. G. Dugan. Mr. Campbell, speaking on "Comparative Calculations on Definite Refrigerants for Low-Temperature Work," was selected as the winner of the competition.



NEW MACHINE SHOP AT COLORADO STATE COLLEGE SHOWING LATHES AT ONE SIDE; NEWER INDIVIDUAL DRIVE LATHES AT EXTREME RIGHT

THE QUEEN—PRESENTATION OF THE MECCA QUEEN AT THE MECCA BALL
(Mecca Ball is the Engineers' Dance held at the State University of Iowa; this year it was attended by 600 couples.)

St. Patrick Celebration at Iowa

According to the stack of newspaper clippings and magazine articles received from John Wessale, chairman of the State University of Iowa Branch, Iowa has for the last 29 years far from forgotten St. Patrick. These clippings describe the 1939 observance of MECCA (mechanicals, electricals, civils, chemicals, and architects) week in honor of St. Patrick. At first, all of the activities were held during the week of St. Patrick's Day, but the exhibition has been moved to May when thousands of high-school students come to Iowa city for the State Music Festival. During MECCA week a queen is selected, and there are an all-engineering smoker, a dance (attended by 600 couples this year), a play, and a banquet (attended by 143 students and faculty this year). Traditional are the green neckties worn by the engineering students, the green flag of St. Patrick flying over the engineering buildings, the battle of the engineers and the lawyers, and the sacred "Blarney Stone." This shows that the State University of Iowa is doing its part in maintaining the memory of St. Patrick, the first mechanical engineer.

Iowa State College Branch had papers presented at the meeting of March 8 by John Larkins, Edward Ott, Walter Gormly, John Keller, and Charles King. Ott won first prize with his "Derivation of Equations for Torsional Vibration in Marine Diesel Crankshafts." Second prize was given to King for his paper entitled, "More Power per Cubic Inch."

Kansas Branch had a meeting on Feb. 23 at which Wray Fogwell read a paper on wrought-iron pipe.

Kentucky Branch has been devoting so much time to inspection trips, joint meetings, etc., that it was necessary to devote the meeting of March 17 to business of the Branch.

Lafayette Branch visited the Ethyl Company's motor clinic at Allentown, Pa., on March 22, where the members saw various engines subjected to various fuel and lubricating-oil tests.

Solution Cycles at Lehigh

On March 23, at a meeting of the Lehigh Branch, Joel F. Bailey, graduate assistant in mechanical engineering, gave a lecture on "Solution Cycles." He explained how, by varying the solutions in a boiler, regular heating units could be transformed into refrigerators. It was pointed out that although this principle is used by several refrigerator manufacturers, it is not employed in furnaces because the solutions are too corrosive.

M.I.T. Branch members made an inspection trip on March 7 to a candy factory, that of the New England Confectionery Co. in Cambridge, Mass.

At a meeting on March 21 of the Maryland Branch, an engineer was defined by Frank T. Leilich, member A.S.M.E., as "a man who can do with $1 what any boob can do with $2." The title of his address was "The Experiences of an Engineer."

Interesting Meetings at Michigan

The evening of March 1 was the occasion of one of the best mechanical-engineering meetings ever held by the Michigan Branch, more than 100 being present. Guest speaker was L. C. Hill, manufacturing manager, Murray Corporation, Detroit, Mich., who presented a paper on "The Engineers' Role in Management." Included in the talk were many interesting topics, two of the more outstanding being "economics" and "personnel" in a large industry. The other meeting on March 22 drew 250 members and guests to see the U. S. Steel Corporation's technicolor sound motion picture, "Steel—Man's Servant."

About 70 members of the Minnesota Branch attended the Student Group Meeting in Chicago, Apr. 17 and 18. During the rest of the week, the boys visited several industrial plants in the Chicago and Milwaukee areas.

Meetings of Nebraska Branch for the last month or so have been devoted entirely to the presentation of student papers in preparation for the Student Group Meeting at St. Louis, May 5–6. Members who presented papers included Vernon Dalby, Joe Brown, Ellis G. Smith, and Richard Ostwald.

Newark Completes Successful Year

Newark Branch is ending one of its most successful years, with 81 active members participating in the various activities. Air conditioning, gas welding, power-plant problems, and aviation were some of the features of past meetings. The concluding meeting in May will be the annual father-and-son night.

New Mexico Branch at its meeting of March 9 had several members present talks based on articles taken from Mechanical Engineering.

N.Y.U. Branch (aero division) is very proud of its new dispatch office where actual problems in air-transport dispatching will be worked out with weather information obtained from the school's meteorological department.

N.Y.U. Branch (evening division) members are displaying considerable interest this semester in marine engineering, probably due to the visits made by the Branch to some of the largest ships in the world which use the port

MEMBERS OF THE UNIVERSITY OF NEBRASKA STUDENT BRANCH

of the City of New York. On March 11, the boys inspected the new fire boat which has just been added to the city's fleet.

N.Y.U. Host to Students on Mar. 17

N.Y.U. BRANCH (mechanical division) played host on the evening of March 17 to a large number of student members from other Metropolitan schools in a gala St. Patrick's Day Celebration. The evening started off with a dinner in the Faculty Club at which time St. Patrick awarded "gifts" to members of the faculty. After dinner everyone tried his hand at writing limericks about St. Patrick. The winner was Fred Reines, of the STEVENS BRANCH. He received a green horseshoe with instructions to hang it over the door of President Davis of Stevens. After hearing talks by Dwight S. Sargent on "Company-Employee Relations" and several other speakers, the student members adjourned to the wind tunnel where airplane models were tested. The students then proceeded to the air-conditioning laboratory.

NORTHEASTERN BRANCH welcomed back a graduate, Elmer Everett, on March 31. Mr. Everett, now with the Birdseye Laboratories, gave a talk on "Frosted Foods."

In a series of meetings during March, members of the PRATT BRANCH presented papers in competition to represent the Branch at the Student Group Meeting in Princeton, N. J. George E. Woodger, who described a "New Design for a Two-Cycle Aircraft Engine," beat out Archie E. Demirgian, Walter B. Moen, Anthony Jonassem, and Carlos E. Stafford for the honor.

PRINCETON BRANCH members visited the General Motors assembly plant at Linden, N. J., and the Wright Aeronautical Corporation plant at Paterson, N. J., on March 15.

Purdue Selects Speakers

A preliminary speech contest was held on March 14 by the PURDUE BRANCH to select candidates for the final contest held on March 29 by the Central Indiana Section for the best talk on "The Kind of Employer I Would Like to Have."

RHODE ISLAND STATE BRANCH had Dr. Lillian M. Gilbreth, member A.S.M.E., as the guest speaker on March 6. Following a tea tendered to her by Miss Alexandra Dobrolet, only female member of the Branch, Dr. Gilbreth gave a talk on "The Challenge to the Young Engineer." More than 150 members and guests were present at the meeting.

MEMBERS OF STUDENT BRANCH AT NEWARK COLLEGE OF ENGINEERING

DEAN RODGERS OF LEWIS INSTITUTE WELCOMES PRESIDENT A. G. CHRISTIE ON BEHALF OF STUDENT BRANCH, JAN. 27

STANFORD BRANCH is making out very well this semester, according to a report received from George L. Sullivan, advisory member of the Society's Committee on Relations With Colleges.

Plans were completed by SWARTHMORE BRANCH on March 16 to have five divisions in its Open House exhibit. These divisions include internal-combustion engines, steam, hydraulics, materials testing, and metallurgy.

Toronto Receives Prof. Christie

Prof. A. G. Christie, President A.S.M.E., was the guest of honor of the TORONTO BRANCH on March 14 at a luncheon which was followed by a meeting which attracted 86 members and guests. The address on "Creative Engineering," according to R. N. Boyd, secretary of the Branch, was an inspiration to all those present.

South Texas Section of the A.S.M.E. was the host at a special meeting on March 10 attended by student members of TEXAS A.&M., TEXAS, and RICE BRANCHES at which students presented papers in competition for $25 in prizes. First prize went to Rudolph Bodemuller, of TEXAS BRANCH; second to J. D. Martin, of TEXAS A.&M. BRANCH; and third to G. W. Staples, of TEXAS A.&M. BRANCH.

TULANE BRANCH did its part at the Spring Meeting of the A.S.M.E. in New Orleans. Many of the members not only attended meetings but also assisted in showing slides for speakers and in many other ways. Donald E. Jahncke, student member, presented a paper, "The Social Responsibility of the Engineer," at the student conference during the meeting.

UTAH BRANCH on March 22 saw a film on the manufacture of safety glass which was presented by Grant Bagley. This was followed by a talk by James Hewes on tires, the material for which was taken from MECHANICAL ENGINEERING.

Ice Cream and St. Pat at Vermont

VERMONT BRANCH celebrated St. Patrick's Day by making a visit to the local plant of the General Ice Cream Company, where, after an inspection of the machinery, the boys were treated to the company's product. Congratulations to F. H. Canary, the hard-working and conscientious secretary of the Branch, for his selection as the Branch's representative at the Student Group Meeting at Ithaca, N. Y.

On March 7, members of the VILLANOVA BRANCH were addressed by Victor Barr, Roller Bearing Co. of America, on the subject of bearings. He described the tests on anti-friction bearings which are being carried out at the school by his company.

GEORGE WASHINGTON BRANCH cooperated with the Engineer's Council of the school in sponsoring joint meetings and lectures during the last semester.

WYOMING BRANCH lost one of its most valued members with the death on March 6 of John Webber, who did so much for the Branch. The large increase in membership was primarily due to his activity. The many friends he made on his visit to New York for the Annual Meeting of the A.S.M.E. in December, 1938, extend their sympathy to the WYOMING BRANCH.

Good News for 1939 Engineering Graduates

NINETY-FOUR per cent of the graduates of the class of 1938 in the college of engineering at Cornell University are known to have found employment, according to a survey recently completed by the school's personnel and employment office. The record shows 100 per cent placement of graduates in chemical engineering and in the administrative engineering course in electrical engineering. Of the 148 graduates in the class, 128 have accepted positions in business or industry, 11 are taking graduate work, and only 9 are not yet employed.

Percentages by divisions follow: Chemical engineers, 100; civil engineers, 87; electrical engineers, 89; mechanical engineers, 95, and administrative engineers 96, divided as follows: in electrical engineering 100, and in mechanical engineering 94. Numbers employed include 14 chemical engineers, 18 electrical engineers, 24 civil engineers, 43 mechanical engineers, and 49 administrative engineers, divided into 10 in electrical and 39 in mechanical engineering. Those taking graduate work included three electrical, one civil, one administrative, and six mechanical engineers.

14th Annual Inspection of N.A.C.A. Laboratories Set for May 2

The National Advisory Committee for Aeronautics has set May 2, 1939, as the date for the 14th Annual Inspection by executives and engineers of the aircraft manufacturing and operating industries and of governmental and aeronautical organizations, including the A.S.M.E., of the N.A.C.A. Laboratories at Langley Field, Hampton, Va. A feature of the program will be the dedication in the afternoon of the new 19-ft pressure wind tunnel and of the new 12-ft free-flight wind tunnel.

However, the program this year will not involve an aircraft-engineering research conference, such as has been held in previous years, but will include visits to and demonstrations in various wind tunnels, the N.A.C.A. tank, the engine-research laboratory, and the flight-research laboratory. Most of those attending, as in previous years, will proceed on the Norfolk and Washington steamboat leaving the Seventh Street wharves, Washington, D. C., at 6:30 p.m., Monday, May 1, and will return on the same steamer the following evening, arriving at Washington, D. C., about 7:00 a.m., Wednesday, May 3. Due to limited facilities attendance must be limited to registered guests. Registration and stateroom reservations on the steamer will be made upon acceptance of invitation and request for reservations addressed to John F. Victory, secretary, N.A.C.A., 3841 Navy Building, Washington, D. C.

Upon the invitation of Joseph S. Ames, chairman of the N.A.C.A., the Society has designated Alexander Klemin, chairman of the Aeronautic Division of the A.S.M.E., as its official representative for the occasion.

Fuel Engineers Chart Research Program

Members of the research committee of Bituminous Coal Research, Inc., at a meeting in Pittsburgh, Pa., March 21, charted a research program that is designed to restore large tonnages of coal to the annual production of the industry. The program is based on a proposed expenditure of $235,000 per year, which will be underwritten by the industry.

The six-point program of technical investigations and service outlined at the close of the meeting included the development of methods and equipment for (1) the completely automatic heating of residences and buildings with a wide range of coals, (2) ceramic and metallurgical heating and melting with pulverized coals, (3) the complete gasification of coal, (4) a coal-dust engine, and (5) the collection and handling of ash without detrimental slagging, clinkering, or discharge into the atmosphere.

While planning the experimental work on these subjects, the committee also proposed a system of coordination of coal research throughout the country by making Bituminous Coal Research, Inc., a clearing house both for problems confronting the coal industry and for research findings that help to solve these problems.

Among the many practical researches completed were the dustproofing of coals with petroleum products, the study of performance characteristics of bituminous coals in residential stokers, the surveys of residential heating and pulverized firing of coal, studies on fundamentals of combustion in stokers, and on segregation of coal in bunkers.

Index of American Standards Available From A.S.A.

An indexed list of American Standards, which includes some 400 nationally approved standards, safety codes, and specifications indexed alphabetically and also industrially according to subject, is available for the asking from the American Standards Association, 29 West 39th Street, New York City. The fields covered include civil, mechanical, and electrical engineering, automotive and aircraft transportation, ferrous and nonferrous metallurgy, chemical industry, textiles, mining, wood, paper and pulp, petroleum products, symbols and abbreviations, and so on.

Most of the standards and codes under the heading of mechanical engineering have been developed under the sponsorship of the A.S.M.E. These are available to Society members through A.S.M.E. headquarters, 29 West 39th Street, New York City, at a 10 per cent discount.

Society of Tool Engineers Elects Weaver President


J. R. Weaver

James R. Weaver, member A.S.M.E., member of the Society's Research Committee on Metal-Cutting Data, executive committee of the Machine Shop Practice Division, Committee on Standardization, and Sectional Committee on Surface Qualities, and director of equipment, Westinghouse Electric & Manufacturing Co., was elected president of the American Society of Tool Engineers at its recent convention in Detroit.

M.I.T. Announces a Course in Statistics

A two-week course from June 5 to 17 for statistical workers in industry who would like to acquire the rudiments of modern statistical technique as applied to the control of quality of industrial products has been announced by M.I.T. The course will include lectures, discussions and laboratory work in large-sample statistics, elementary small-sample theory, correlation, and the analysis of variability in quality.

American Engineering Council

Presents

The News From Washington and Elsewhere

Federal Relations to Research

American Engineering Council over many years has interested itself in promotion of research as a fundamental and primary policy for the creation of new industries, the efficient improvement of technology, the increase of opportunities for employment, and in general, the social and economic welfare of the nation.

This subject is actively before each Congress and the present Congress is no exception. As would be natural, the main argument for government action in various directions for research this year rests upon the possibilities of increasing employment.

It is natural also that this subject should be approached from as many angles as the minds of the different authors of the bills suggest. Some of them tend to centralize and coordinate research into a sort of master agency of the federal government under whose sponsorship funds would be allocated in various ways to both government bureaus and to semipublic agencies and to educational institutions. Such was the intent of H.R. 7939, the Randolph bill, so-called, proposed last year on which no final action was taken.

Other bills are much more specific in character, concerning themselves with the establishment of specific undertakings such as the four regional laboratories set up by last year's Congress under the direction of the Department of Agriculture for which $1,000,000 each was appropriated. Others are approached from the point of view that technology and the economic developments growing out of technology are responsible for the present unemployment. Suggestions have already been made to recommend the taxing of machinery as a method of balancing employment and technological advance.

In the preamble to the bills there is much confusion of terminology and much need for clarification of what is meant by the term, research. Dr. Lyman J. Briggs, Director of the National Bureau of Standards, in his leading discussion at the Detroit Forum of American Engineering Council on "Invention and the Engineer's Relation to It," suggests Julian

Huxley's four categories of research. At one end is background research, with no practical objective consciously in view, such as atomic physics. Next, basic research, which must be quite fundamental in character but has some distant practical objective, such as the study of fluorescence, with the distant possibility of producing cold light. Third, there is ad hoc research with an immediate objective, like research on discharge tubes for lighting purposes. Finally we have what industries call development or engineering research, which is the work needed to translate laboratory findings into full-scale commercial practice. As Huxley says, these categories overlap and interlock, but they form convenient pigeonholes.

American Engineering Council in early studies of this question has attempted to clarify, without official action, certain principles which may guide the authors of the many proposals to what seems to engineers to be the right relationship between the federal government and research. In these analyses it has seemed clear: (1) that the federal government may properly aid fundamental research in present federal bureaus and establishments; (2) that the government may stimulate and assist research at educational institutions and such nonprofit-making laboratories as may be best prepared to serve the public; and (3) that these various aids should be extended so as not to interfere with private enterprise. Since it is obvious that the fundamental purpose of research can succeed practically so far as employment is concerned only when private industries individually accept this as a method of projecting new industry, the expansion of existing industry, the increase of employment in industry, and the steady distribution of the products of industry through reduction of cost.

The National Resources Committee has made several admirable summaries of present projects but the National Resources Committee approaches this total problem from the viewpoint of generalizing as to the values rather than projecting specific methods of accomplishment.

So far as the federal government is concerned these specific methods of accomplishment and the broader matter of philosophy outlined take the form of bills introduced into Congress from the many points of view as already indicated.

As pointed out by Dr. Briggs, the federal government is already spending several millions of dollars for research.

The question then comes as to the practical methods whereby the federal government may by further grants of money extend the purposes and promote the fruits of research in terms of employment without confusion or duplication of effort. This is an enormously difficult question and most of the proposers of the various types of research legislation do not realize the complications and ramifications of their proposals.

Recent inquiries in informed governmental agencies seem to indicate that the present Congress is not disposed to add moneys to those already allocated to independent government agencies, to semiprivate nonprofit institutions, or to educational institutions, except on some 50–50 basis. It is, moreover, evident that any federal moneys must presuppose some federal control of those expenditures and here again there is confusion as to where this federal control should be placed. Of these newer proposals, according to one authority, the so-called Lea bill, H.R. 3652, comes closest to being in line with the principles stated. However, there is doubt whether during this Congress any bills of this sort will reach actual consideration by vote.

One indication of this latter belief is found in the latest resolution on this subject introduced in the House of Representatives on March 28, 1939, by Charles I. Faddis, of Pennsylvania, in which a committee to be known as the Committee on Technological Unemployment is proposed and a sum of $200,000 is to be appropriated from the Treasury of which $150,000 shall be available to the Secretary of Labor for the collection, preparation, and the analysis of materials and $50,000 for public hearings. It is proposed that the Committee shall report its findings to the Congress on or before June 1, 1940. At this writing, this joint resolution, which for passage must be passed by both the Senate and the House, has not come to vote.

This whole subject needs leadership not now available, in part because of the diverse interests involved, sometimes competitive, and in part because the subject itself is so complex that it needs to be studied in the same spirit and from the same long-view and statesman-like attitude as is made evident in certain findings of British Commissions with the intent of establishing a national policy for long-view objectives rather than piece-meal and confusing and overlapping activities.

Committee on Cost Price Relationships Formed

THE National Bureau of Economic Research, Inc., on which engineers are represented by F. M. Feiker, executive secretary of the American Engineering Council, has just announced that its Conference on Price Research has created a new standing committee on cost-price relationships. In attempting to improve methodology, the committee has begun an inventory of published research and has commissioned its staff assistant to prepare a monograph on methods of analyzing the behavior of the short-run costs of individual firms. The committee hopes to stimulate and coordinate research in cost-price relationships as well as to initiate and supervise certain projects of its own. With this in view, it is hoped that persons interested and active in cost-price research will help this group keep in touch with research currently in progress. Communications should be addressed to Joel Dean, National Bureau of Economic Research, Inc., 1819 Broadway, New York, N. Y.

Men and Positions Available

Engineering Societies Employment Service

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 21, Cornell, 1938, automotive specialization; 3 months' experience office computations for large truck fleet. Desires automotive work. Me-271.

INDUSTRIAL ENGINEER, employed; 4 years' experience supervising time study and standards department; installing bonus plans; planning and scheduling; costs; plant layout; and teaching. Technical papers. Desires production engineering or teaching. Me-272.

MECHANICAL ENGINEER, 23, graduate Southern school; employed; 20 months' training course and varied experience large manufacturing company. Desires connection in power or industrial field in South. Opportunity for advancement, salary secondary. Me-273.

MACHINE DESIGNER, 34, married; 10 years in inventing, designing, estimating, and developing automatic machines; 2 years as time study and piecework supervisor, 1 year, machinist; 4 years, machinist apprentice. Me-274.

INDUSTRIAL ENGINEER, two university degrees. Creative ability, broad experience in design, construction, operation, selling in package, bulk-handling, and process fields; chief engineer 18 years; New York professional engineer. Me-275.

RECENT GRADUATE, mechanical engineering, 23; 4 years' cooperative experience with conveyer manufacturer; 2 years' designing, drafting, planning conveyers. Desires engineering position with conveyer manufacturers or instructor in mechanical subjects in college. Me-276.

MECHANICAL ENGINEER, 26, single; Cornell graduate. Experience in testing air compressors, blowers, turbines, refrigeration units, etc.; plant layout, development, maintenance and production engineering work. Can handle men. Will travel. Me-277.

GRADUATE MECHANICAL ENGINEER, 37; broad experience in development and design of heavy machinery; capable of contributing original ideas, wishes to make change. Me-278-8694-Chicago.

PROFESSOR, B.S.M.E., M.S.M.E., M.E.; 20 years teaching mechanical-engineering subjects. Practical experience during summers and in consultant work. American; age 44. Me-279.

GRADUATE MECHANICAL ENGINEER, broad shop and foundry practice, construction and design of heavy machinery, and extended experience in domestic and foreign sales; speaks four languages; desires representation, preferably New York. Me-280.

INSTRUCTOR IN MECHANICAL ENGINEERING, 25; single; M.I.T. graduate, master's degree. Desires position teaching heat engineering in all phases. Now in third year instructing thermodynamics and engineering laboratories. Me-281.

GRADUATE MECHANICAL AND ELECTRICAL ENGINEER, 39; 15 years' experience industrial and public-utility management and consulting

(*A.S.M.E. News continued on page 422*)

[1] All men listed hold some form of A.S.M.E. membership.

Quiet, vibrationless operation is characteristic of the C-E RAYMOND BOWL MILL

MANY ENGINEERS have stood in front of a Bowl Mill for the first time and actually asked, "Is it operating?"—and were incredulous until their attention was called to the rotation of the motor shaft.

Until the Bowl Mill was placed on the market a few years ago, there was no such thing as a pulverizer that you could stand beside with any doubt as to whether or not it was operating. And, except for the Bowl Mill, this is still true.

Why all this emphasis on "quietness?" Simply for this reason. Silence is more significantly eloquent in machines than in men, especially in machines like pulverizers. Eloquent of fine design and construction—of balance—of vibrationless operation—of absence of wearing, metal-to-metal contact. It promises long life—trouble-free operation—low maintenance.

However, the fact that a machine is entitled to first ranking on any one characteristic, even so significant a one as quietness, is not necessarily a criterion that it is the best machine of its kind. In the case of pulverizers, there are the commonly accepted measures of performance—reliability, power consumption, maintenance, capacity and fineness—and there are also special advantages. The Bowl Mill has conclusively proved in service not only that it assures excellent results with respect to *all* the usual measures of good pulverizer performance but also that it possesses such special advantages as quiet, vibrationless operation, ability to handle high temperature air, positive lubrication and convenience of adjustment and control. For these reasons, it is being widely characterized today as the best pulverizer ever developed.

Be sure, then, when next you are in the market for pulverizers, to investigate these advantages—the reasons why the Bowl Mill assures them and the facts that prove them. The reasons are given in a new catalog—write for a copy. The supporting facts can be obtained first hand by visiting a Bowl Mill installation.

A-433

COMBUSTION ENGINEERING COMPANY, Inc.

200 MADISON AVE., NEW YORK, • CANADA: *COMBUSTION ENGINEERING CORPORATION, LTD.*, MONTREAL
All types of Boilers, Furnaces, Pulverized Fuel Systems, Stokers, Superheaters, Economizers and Air Heaters

engineering. Now employed but desires connection affording opportunity for greater progress. Me-282.

DESIGNING ENGINEER, 28; married; M.E. Wisconsisn, '32; 2 years' superintending design building equipment, heating, ventilating, plumbing; $1^1/_2$ years' mechanical design filtration plant. Desires position as assistant designer building equipment or power plant. Me-283.

MECHANICAL ENGINEER, 22, single; graduate Stevens Institute 1939. Desires placement in training course with manufacturer of industrial instruments or equipment; or as cadet engineer in steam-generating plant. Me-284.

INSTRUCTOR, desires permanent teaching position in mechanical or industrial engineering. Now working for M.S. while carrying full teaching load. Has B.S. in M.E. and broad industrial experience. Me-285.

MANUFACTURER, 51; good personality; per fect health; forced out of plastic-novelty business; desires worth-while connection manufacturing, selling, or designing. Will go anywhere. Me-286.

INDUSTRIAL ENGINEER, 23, single; graduate mechanical engineering, University of Mexico, 1938; will graduate business administration, 1939; clerk, U. S. Geological Survey, 2 years; laboratory assistant, Water Resources Division. Southwest preferred. Me-287-393-D-7-San Francisco.

EXECUTIVE ENGINEER, 14 years' experience management, budgetary control, standard costs, planning, personnel, wage systems, rate setting, purchasing, maintenance buildings and machinery, machinery installation; 8 years textiles. Available May 1. Me-288.

GRADUATE MECHANICAL ENGINEER, single, 28; broad experience in boiler, locomotive, and general machinery maintenance; knows steel construction; desires position as equipment erector; will travel; available July. Me-289.

POSITIONS AVAILABLE

MECHANICAL OR MINING ENGINEER, 30–35, graduate recognized engineering school. Must have stood well in classes, and had at least 3 or 4 years' practical experience in metallurgical or ore-dressing plant design. Should be thoroughly familiar with ore-dressing operations, and have specialized in plant layout and equipment design. Prefer mechanical engineer, specialist in ore-dressing-plant design, and experienced in machinery installation and plant operation. Location, South. Y-4004.

RESEARCH ENGINEER, not over 45, with experience in the manufacturing and weaving of cotton tape. Salary, $4000 a year. Location, western Pennsylvania. Y-4015.

RESEARCH ENGINEER, textile graduate. Must be specialist in cotton and rayon research, and must be particularly adept in mathematics. Must have creative ability to think out and handle construction research problems. Experience in these lines is essential. Salary, $300–$400 a month. Location, Middle West. Y-4018C.

MACHINE DESIGNER experienced in automatic and general machine designing. Must be able to do original work, lay out and supervise the work of detailing and installation. Salary, $60 a week. Location, New York State. Y-4029.

TESTING ENGINEERS, one mechanical and one electrical. Must be capable of designing and developing machines and methods for the testing of materials and appliances in the process industry. Only men experienced in this work will be considered. Location, Ohio. Y-4033C.

DESIGNER, with experience in process design and line production with a concern manufacturing metal cabinets; knowledge of electric-welding-machine design. Salary, $40–$60 a week. Location, Ohio. Y-4034C.

ELECTRICAL ENGINEER, take charge of installation and maintenance of equipment in several large associated plants, also boiler and powerhouses connected with these plants. Must be thoroughly capable with broad experience, preferably with power-plant operation or design experience, and able to take full charge of power plants. Location, Pennsylvania. Y-4037.

GRADUATE MECHANICAL OR ELECTRICAL ENGINEER, 27–32; preferably married, for export sales-promotional work. Must have thorough command of the English language and previous commercial experience in sales or sales-promotional work. Experience in the use of dictaphone or ediphone is essential; knowledge of Spanish desirable. Opportunity. Salary, $40 a week. Apply by letter giving résumé of education and experience, including names of former employers, etc. Location, New York, N. Y. Y-4041.

MECHANICAL OR ELECTRICAL ENGINEER, not over 30, with patent experience. Must have been employed by patent attorney preparing applications for patents. Salary, $50 a week. Location, New York, N. Y. Y-4046.

GRADUATE MECHANICAL ENGINEER, 25–30, for research work. Should have background in physics or electricity, and must have had experience in designing small instruments. Salary, $200–$250 a month. Location, Middle West. Y-4050C.

MECHANICAL ENGINEER, 25–35, with experience in design of cables, winches, control equipment, large-instrument manufacture, etc. Salary, $200–$250 a month. Location, Middle West. Y-4051C.

INSTRUCTOR, to teach engineering mechanics and strength of materials, materials-testing laboratory and research work in both mechanics and materials testing. Must have degree in engineering from recognized American or foreign school, and a master's degree in mechanics or its full equivalent in industrial experience in immediate field of mechanics. A doctor's degree desirable. Salary, $1800 a year. Location, East. Y-4056.

CHIEF ENGINEER, graduate mechanical engineer for manufacturer of refrigerating equipment and small mechanical mechanisms such as are used in vending machines. Should have had experience in similar lines of equipment such as typewriters, adding machines, etc. Salary, $5000 a year. Location, Middle West. Y-4064-R-675C.

INSTRUCTOR, young, to teach general physics, both laboratory and quiz sections. Must have majored in physics, and have done some graduate work. Teaching experience not as essential as thorough grounding in subject matter. Salary, $1200–$1500 a year. Location, East. Y-4065.

MECHANICAL ENGINEER, 35–50; to act as quality manager. Must have thorough knowledge of inspection procedure in precision manufacture, particularly metal finishes, close limits, tolerances, etc. Should have exceptionally good personality and tact, as he will come in contact with high government officials. Location, East. Y-4085.

DESIGNER, experienced in the design of dies, jigs, and fixtures. Must be able to improve production methods, and should have knowledge of the cost of dies. Salary, $50–$60 a week. Location, New York State. Y-4087.

FOREMAN, to run a machine shop, design and make dies, and take charge of small production department. Must understand plating. Salary, $50 a week. Location, New York State. Y-4088.

DESIGNING ENGINEER OR DRAFTSMAN, with experience in design of centrifugal compressors, particularly as used in air-conditioning industry. Location, New Jersey. Y-4091.

MECHANICAL ENGINEER, 35–40; for estimating on machine-shop operations. Must be thoroughly experienced in taking time and costs from blueprints on drilling, milling, and grinding operations. Location, New York, N. Y. Y-4094.

DEVELOPMENT AND TEST ENGINEER, technical graduate, young, with theory and experience in centrifugal pumps, steam turbines, and steam locomotives. Must be physically able to do test or service work. Apply by letter giving full qualifications, age, recent photograph, salary expected, etc. Location, New England. Y-4096.

GRADUATE MECHANICAL ENGINEER, about 25, with practical experience in heavy machinery, either with a manufacturer or user. Will be trained for sales work in field. Location, Middle West. Y-4097C.

GRADUATE MECHANICAL ENGINEER, about 30, to act as assistant to sales manager. Must have had experience in heavy machinery. Location, Middle West. Y-4098C.

MECHANICAL SUPERINTENDENT, graduate mechanical engineer thoroughly experienced in all phases of mechanical, electrical and steam engineering, and general maintenance. Position is with large company operating several factories. Must be aggressive, and must be able to handle large volume of detail in connection with maintenance of equipment. Apply by letter stating age, education, past experience and earnings, and salary expected. Location, Middle West. Y-4100C.

LABORATORY ASSISTANTS, two, one for mechanics and one for mechanical-engineering laboratory of eastern technical college. Must have been graduated from well-known technical colleges. Part time may be devoted to extra curricular study. Salary, $700 a year. Y-4104.

MECHANICAL ENGINEER, 35–55, with approximately 15 years' experience in power station design, steam side. Salary, $350–$400 a month. Location, New York, N. Y. Y-4106.

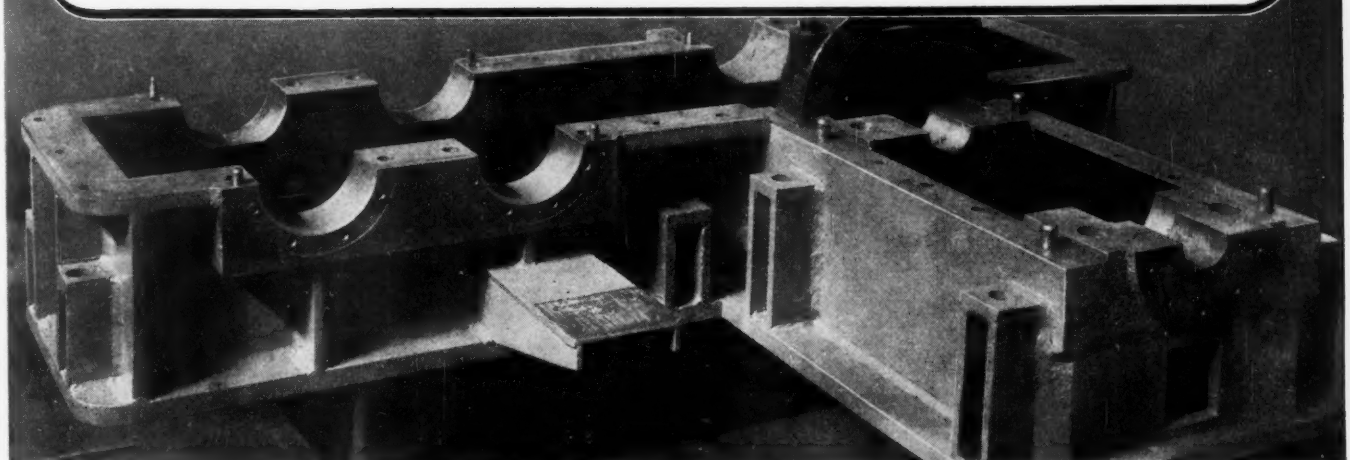
RESEARCH ENGINEER, to investigate and eliminate causes of noise in shop ventilating systems. Should have thorough knowledge of vibrations in metals and balance in rotating machinery. Salary, $20 a day. Location, New York, N. Y. Y-4108.

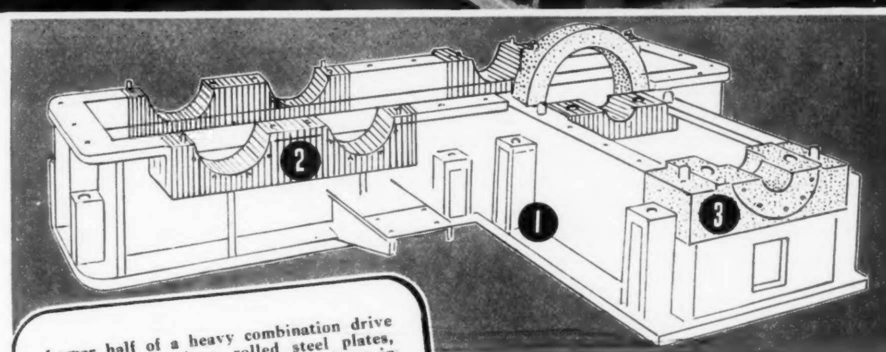
(*A.S.M.E. News continued on page 424*)

TO MAKE YOUR ROLLED STEEL CONSTRUCTION

More Efficient...

we offer these More Efficient Steels





Lower half of a heavy combination drive unit fabricated from rolled steel plates, slabs, and cast steel parts. Sketch shows in white (1), parts fabricated from plates; in hatched areas (2), parts flame-cut from slabs; in dotted areas (3), cast steel parts. Rolled steel construction makes it possible to combine effectively the right steels for maximum functional efficiency.

U·S·S HIGH TENSILE STEELS

To carry high unit stresses and to reduce weight to a minimum at low cost. (U·S·S Cor-Ten has resistance to atmospheric corrosion 4 to 6 times greater than plain steel.)

U·S·S ABRASION RESISTING STEELS

To reduce abrasive wear wherever earth, sand, gravel, waste, etc., flow over, through or against your equipment. Costs little more than plain carbon steel.

U·S·S CARILLOY ALLOY STEELS

To strengthen vital parts—to carry tremendous bearing pressures safely. Steels to resist creep at elevated temperatures and pressures.

U·S·S STAINLESS STEELS

To resist corrosive environments. To assure long life. Special analyses can be welded with no loss in corrosion resistance.

U·S·S HEAT RESISTING STEELS

To endure high temperatures that spell disaster to other metals.

THE advantages of rolled steel construction are many. Light weight, lower cost, improved appearance, freedom of design—these are the reasons why designers are now turning to this method of building equipment.

You can sum up all these advantages with this single statement: *Rolled steel construction permits the ultimate in functional efficiency.*

To make the most out of rolled steel construction, we offer you the widest available range of metallurgy's finest steels, plus the services of experts trained in the job of selecting the right steel for a given application. You can rely on our specialists' recommendations, because they have a complete range of steels from which to choose. They are not interested in promoting any one grade or alloy over any other. Their sole interest is in helping you get the steel that will do the best job at lowest cost. Ask one of these engineers to call.

USS

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

TESTING ENGINEER, 28-30, graduate mechanical engineer for purchasing department of a company to test, submit reports on, and recommend for purchasing all equipment the department considers buying for the company's service stations, such as lubrication guns, racks, lifts, brake testers, instruments, tools, battery chargers, etc. Should be familiar with service-station equipment and operation from every angle, also with brake, battery, and lubrication service in order to determine the value of the equipment in rendering service. Salary, $200-$225 a month. Location, Middle West. Y-4113C.

CHIEF DRAFTSMAN, 35-50, capable of designing and developing light and heavy machinery. Must also be capable of laying out system in drafting room, and standardizing parts for manufacture. Knowledge of printing and paper-container machinery desirable. Location, New York, N. Y. Y-4119.

Interview Facilities Offered A.S.M.E. Members by Society

FACILITIES for interviewing applicants for positions by local and out-of-town employers, who are members of the A.S.M.E., are available at Society headquarters in New York. Requests may be made through the Engineering Societies Employment Service. Advantages of this free service to members are the use of private rooms for interviews, a waiting room for applicants, and the services of the Society's receptionist. This obviates the trouble and cost of renting a hotel room by out-of-town employers.

Local Sections

Coming Meetings

Anthracite–Lehigh Valley: May 26. Hazleton, Pa., at 8:00 p.m. Historical Meeting with about six papers to be presented dealing with mechanical developments and the early contributions of mechanical engineering to the coal industry. Will treat of inventions as well as the lives of some of the engineers who pioneered in this field.

Cleveland: May 1. Case Club, 10700 Deering Ave. S. E., Cleveland, Ohio, at 7:00 p.m. The Section will join with the Case Student Branch in a dinner and meeting featuring the Alleghenies Group Conference which will be in session at that time. This will be purely a social meeting.

Ontario: May Meeting. Hamilton, Ontario. Joint meeting with the Engineering Institute of Canada, Hamilton Branch. Subject: "Air Brakes," by Joseph McCune, director of research, Canadian Westinghouse Co., Ltd.

Philadelphia: May 25. Annual Meeting and Dinner Dance (place not determined). Installation of new officers. Mr. Harte Cooke, senior councilor of the A.S.M.E., will attend this meeting.

Worcester: May 17. Sanford Riley Hall, Worcester Polytechnic Institute. Dinner, 6:45 p.m.; meeting, 7:45 p.m. Subject: "Application of Modern Elastic Theory to Engineering Problems," G. H. MacCullough, Worcester Polytechnic Institute.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after May 25, 1939, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Reelection; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member

NEW APPLICATIONS

For Member, Associate, or Junior

ANDERSON, NILS, JR., Montclair, N. J.
BEATON, NORMAN H., Glendale, Calif.
BURNS, FRANCIS J., East Orange, N. J.
CANNON, ARTHUR H., Charleston, W. Va.
CARRIERE, J. G., Wilmington, Calif. (Re)
DAWSON, GERALD T., Quebec, Canada
FLOEHR, WALTER L., Toledo, Ohio
FULLER, NORMAN C., Toledo, Ohio
GATES, F. R., Ontario, Canada
GATES, WALLACE G., Clintonville, Wis.
HAWLEY, CHAS. FREEMAN, Holden, Mass.
HIDALGO, CLEMENTE, Manila, P. I.
HINDS, WILBUR H., East Alton, Ill.
HOLMES, A. G., JR., State College, Miss. (Rt & T)
JOHNSON, A. A., Kew Gardens, L. I., N. Y.
KING, FREDERIC C., JR., Torrance, Calif.
KNAUS, WM. L., Ft. Wayne, Ind.
KRAMER, KARL S., Norwood, Pa. (Rt & T)
KRUSE, JOHN F., Alton, Ill.
LANEY, J. T., Jackson, Miss.
LEVINE, HERBERT P., Reading, Pa.
LEWIS, CHAS. F., Columbus, Ohio
LOVELAND, ROBT. P., Ft. Wayne, Ind.
MAXWELL, CARL A., Akron, Ohio (Rt)
MAYES, M. S., West Point, Va.
McCABE, I. E., Chicago, Ill.
McINTYRE, R. B., Toronto, Ont., Can. (Re)
McKEE, WAYNE S., Pittsburgh, Pa.
MILLER, FRANK D., Buffalo, N. Y.
MILLER, J. GILBERT, Charleston, W. Va. (Rt)
OSGOOD, CAROL E., Boston, Mass.
PEEBLES, JAS. C., Chicago, Ill. (Rt)
REED, MALCOLM V., Houston, Tex.
ROSE, B. A., Wilkinsburgh, Pa.
SCHNEIDER, FRED B., Wesleyville, Pa.
SHARFSTEIN, PHILIP, Middle Village, N. Y.
SHERWOOD, NOBLE P., Dallas, Tex.
SHIBA, K., Tokyo, Japan
SMITH, JOHN FREDK., Boston, Mass.
STETTNER, H. W., Beloit, Wis. (Re)
STROM, RUSSELL, Rome, N. Y. (Re)
SWANSON, MAURICE C., Scotia, N. Y.
SWENSON, HAROLD A., Martinez, Calif.
TATE, M. G., New York, N. Y.
TURNBULL, WM. A., JR., Trona, Calif.
VANCE, HAROLD, Bryan, Tex.
WEISMANN, GEO. F., Alhambra, Calif. (Rt)
WILSON, HARRY R., Newark, N. J.
WOSAK, ROBT., Quaker Hill, Conn.

CHANGE OF GRADING

Transfers to Fellow

COOKE, HARTE, Auburn, N. Y.
HUNTER, JOHN, Winter Park, Fla.

Transfers to Member

BROWN, WARREN A., Edgewater Park, N. J.
PARKER, CHAS. E., Newark, N. J.
ROSS, CARROLL A., Buffalo, N. Y.
SINGER, FERDINAND L., New York, N. Y.
SIZER, HAROLD S., Pawtucket, R. I.
STAPLES, FRANK C., Floral Park, L. I., N. Y.
WHEAT, OSCAR G., Beaver Falls, Pa.

A.S.M.E. Transactions for April, 1939

THE April, 1939, issue of the Transactions of the A.S.M.E. contains the following papers:

Development of the Focke Helicopter, by Heinrich Focke
The Interpretation of a Failure of an Ordnance Structure, by G. F. Jenks
The Use of the Piezoelectric Gage in the Measurement of Powder Pressures, by R. H. Kent and A. H. Hodge
The High-Pressure High-Temperature Turbine-Electric Steamship "J. W. Van Dyke," by L. M. Goldsmith
Rollcurve Gears, by H. E. Golber
Nozzle Coefficients for Free and Submerged Discharge, by R. G. Folsom
Creep in Tubular Pressure Vessels, by F. H. Norton
Effect of High Temperatures and Pressures on Cast-Steel Venturi Tubes, by W. S. Pardoe
Twenty Years of Machine Activity in the Woolen-and-Worsted Industry, by A. W. Benoit
The Elastic Theory of Wood Failure, by C. B. Norris

DISCUSSION

On previously published papers by W. J. Wohlenberg and D. E. Wise; O. F. Campbell; R. M. Hitchens and J. W. Purssell, Jr.; A. Vigne and I. E. Cox; and C. J. Coberly